



Conservation Practices for Small-Scale Hawaiian Farms



Submitted in partial fulfillment of:
USDA-NRCS Conservation Innovative Grant
NRCS#69-3A75-11-212

June 15, 2015

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This material is based upon work supported by the Natural Resources Conservation Service, U.S. Department of Agriculture, under Conservation Innovative Grant # NRCS#69-3A75-11-212. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the views of the U.S. Department of Agriculture.

Table of Contents

Introduction	1
Ahupua'a System of Land Management	2
Soil Erosion and Agricultural Activities Causing Erosion	3
Effects of Soil Erosion	4
Identifying Conservation Practices for the Farm	4
Practices to Minimize Erosion from Bare Soil	6
Practices to Minimize Soil Loss on Slopes	9
Addressing Sediment, Nutrient, and Pesticide Runoff from Fields	10
Animal Management Practices	11
Practices Designed for Heavy Use Areas	13
Countering Excessive Runoff and Flowing Water	14
References	15
Photo Credits	16
Appendix 1: Conservation System Guides for Pacific Basin Farmers and Ranchers	17
Access Roads	
Alley Cropping	
Contour Farming for Cropland	
Contour Farming for Orchards	
Cover Crops and Conservation Covers for Better Harvests	
Fencing	
Grassed Waterways	
Heavy Use Area Protection	
Hillside Ditches for Steep Slopes	
Mulching for Moisture, Weed Control and Soil Protection	
Nutrient Management	
Prescribed Grazing	
Protecting Soil	
Residue Management: Using Plant Residues (Slash) for Moisture, Weed Control, and Soil Protection	
Roof Runoff Structures to Improve Farm Drainage	
Vegetative Barriers for Protecting Topsoil	

Guide to Protecting Water Quality by Controlling Erosion on Small Farms in Hawaii

Healthy Hawaiian Watersheds Begin in Your Own Fields!

THE PURPOSE OF THIS HANDBOOK IS to provide small-scale farmers on the Hawaiian Islands with the information necessary to implement effective soil management practices on their farms, with specific focus on soil and water conservation. Small-scale farms are becoming more common in Hawai'i as plantation agriculture involving sugarcane and pineapple has diminished, diversified agriculture has gained a firm foothold, and markets for fresh, local produce have expanded. Small-scale farmers are producing food to feed their families, to meet the increasing demand for locally and sustainably grown agricultural products, and to move the Islands, which import between 60-70% of fresh fruits and vegetables alone, toward food self-sufficiency.



IF YOU OPERATE A SMALL FARM IN HAWAII'I, this handbook will show you how to attain and maintain productive soils, while keeping sediment and other pollutants out of Hawai'i's **waterways**, and protecting Hawai'i's **native plants, animals, fish, and scenic beauty**. The key is to follow sustainable land use principles, and apply natural resource conservation practices that are proven to be effective on small farms. Many practices



designed to reduce soil loss and runoff pollution also increase productivity and save farmers money in the long run.

An important feature of effective conservation is to encourage multiple adjacent farms within a **"hydrologic" land unit to work together toward** achieving their common goals. While this concept is now considered innovative, it is similar to the approach practiced by Ancient Hawaiians in the traditional Ahupua'a system of land management.



HAWAII'S FARMERS TODAY HAVE MANY OF THE SAME CHALLENGES AS HAWAIIAN FARMERS OF THE PAST

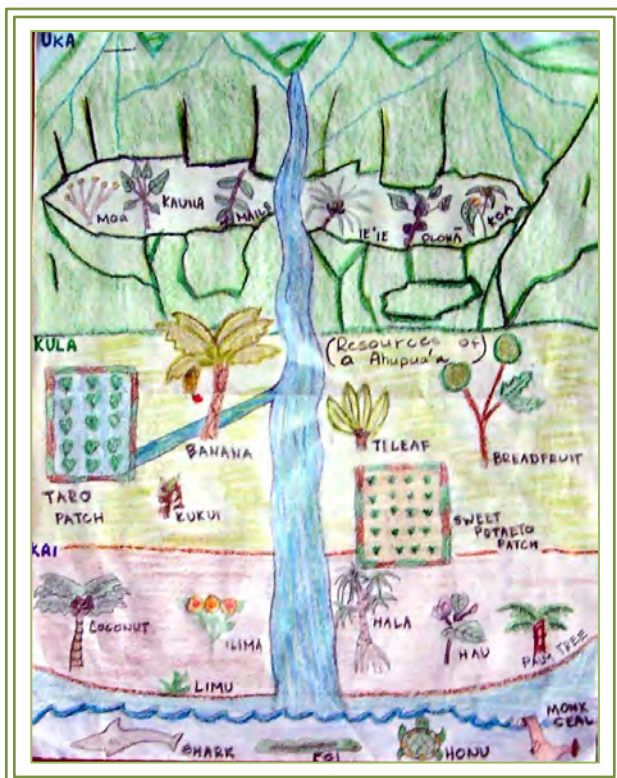
with respect to keeping their farms productive, protecting the land and keeping the waters running from the mountains to the ocean clean and clear.

Many small farms are located in areas of plentiful rainfall and on slopes where runoff and soil loss from fields are serious problems.



Conservation Practices for Small Scale Hawaiian Farms

ANCIENT HAWAIIANS were skilled at managing watersheds to protect land and water resources and to produce the materials needed to secure food and shelter. The traditional land division, or ahupua'a, was a wedge-shaped area of land running from the uplands to the sea following the natural boundaries of the watershed. Each ahupua'a contained the resources the human community needed: fish and salt in lowland kai areas; fertile land of the kula for farming crops such as taro and sweet potato; and bird feathers, koa and other native trees growing in upslope areas of the uka. Streams provided freshwater fish and shellfish. Each ahupua'a was viewed and managed as a unified system. What happened in any one part of the ahupua'a affected all of the other parts. The head was connected to the tail, the mauka connected to the makai. The people worked as a community with a shared interest in protecting the land and water resources from wao (forested upper elevation regions) to kai (shoreline, beach, and coastal zone).



"As the native Hawaiians used the resources within their ahupua'a, they practiced aloha (respect), laulima (cooperation), and malama (stewardship) which resulted in a desirable pono (balance). This is sound resource management where the interconnectedness of the clouds, the forests, the streams, the fishponds, the sea, and the people is clearly recognized," Carlos Andrade, University of Hawai'i at Manoa.

As in ancient times, the mountainous uka continues to supply clean water, wood, and other forest products. The fields of the kula provide crops and the kai provides marine resources. Although the traditional boundaries may not be as obvious today, **Hawaii's ahupua'a remain as unified systems.** What happens in the uplands affects life below. When forests and uplands are managed to prevent erosion of fertile soil and to keep streams and rivers clean and clear, watersheds are healthy and waters flowing into the ocean allow its resources to thrive. **With increasing pressure on Hawaii's** natural resources and a growing interest in creating a self-sustaining lifestyle, people are now looking to the ahupua'a for answers. By working to manage their farms as part of an integrated watershed, or ahupua'a, **Hawaii's small scale farmers can ensure a sustainable resource base for future generations.**



WHAT IS SOIL EROSION? Soil erosion is the breaking apart, dissolving, wearing down, transportation, and deposition of rock and soil. It is caused by water, wind, animals, humans, and gravity. Some erosion is natural, but poor farming, ranching, forestry practices, and inappropriate construction activity can greatly speed up soil loss from farms and cause damage to the eroded sites as well as low-lying land and water resources.

Throughout the islands erosion tops the list of agricultural conservation issues. A conservation plan based on protection of the soil will also protect other natural resources. When you lose topsoil, you lose organic matter that is essential for soil health, plant growth (crops, trees, food for livestock and wildlife), soil moisture, infiltration, carbon storage, and much more.

Hawai'i is the only U.S. state which lies in the inter-tropical zone. Residents have observed, and research has confirmed that climate, especially rainfall, is 2-3 times more aggressive in inducing soil erosion in the Pacific Islands than in the continental U.S.

Although aggressive climate can be a decisive factor in determining erosion potential the wide **diversity of Hawai'i's soils and land uses ultimately determines** the likelihood and extent to which erosion will actually take place at a given site. Therefore, **conservation-effective land use and management** are imperative for sustaining land productivity and maintaining environmental quality.

AGRICULTURAL ACTIVITIES that cause accelerated runoff and soil loss can also impair the quality of surface water resources and coastal areas due to their loads of sediment, nutrients, pesticides, and other pollutants. **Many of Hawai'i's coastal areas and estuaries have been affected** in this way. Agricultural practices that lead to erosion and runoff include:

- land clearing, including poorly-managed or ill-timed crop harvesting operations
- leaving the soil fallow or bare during the rainy season or windy periods
- leaving soil surface exposed (e.g. un-vegetated)
- building and travelling over unpaved roads
- planting crops parallel to, rather than across the prevailing land slope
- excessive intensive grazing
- allowing animals to graze close to streams and waterways
- plowing too often or at the wrong time
- improper, excessive, or poorly timed applications of pesticides, and fertilizers

Even important groundwater supplies in Hawai'i's aquifers can be contaminated by leaching when fertilizers (including manure) and agricultural chemicals are used in excess of crop needs. Farmers should focus on how fertilizers and pesticides are used efficiently, rather than aiming for unrealistically high crop yields.



SOIL EROSION RESULTS IN PROBLEMS ON FARMS AND DOWNSTREAM BECAUSE:

- It washes away valuable topsoil rich in nutrients and organic matter, making fields less fertile.
- It may wash away large sections of stream bank.
- Soil (or sediments) can clog streams and rivers causing flooding problems on-farm and downstream.
- Soil can silt in reservoirs, cover fish spawning grounds, and reduce downstream water quality.
- Sediment increases murkiness of water making it difficult for aquatic plants to get light and harms unique endangered stream animals 'o'opu (fish), 'ōpae (shrimp), and hihiwai (snails).
- Soil settling on coral can kill reefs, damaging island fishing areas and seaweed populations.
- It may wash away pesticides and nutrients, causing water pollution that is harmful to people and to fish and other water creatures.



Sediment pollution of Pearl Harbor



Urban development and agriculture are the most significant threats to Hawaiian coral reefs because of runoff containing sediments, chemicals and nutrients.

DECIDING WHAT CONSERVATION PRACTICES ARE RIGHT FOR YOUR FARM WILL DEPEND ON a number of things such as soil type, slope, rainfall, presence of seasonal or perennial streams, farm history, whether you are raising tree crops, row crops, or ranching, and conservation practices that are already in place. Certain areas on your farm are more susceptible to erosion than others. Areas with very steep slopes, ephemeral gullies or gulches, and exposed stream banks should be avoided for agricultural and ranching uses.

Areas that are suitable for farming and that will require extra erosion protection include:

- areas with long and/or steep slopes
- areas with very erodible soils
- areas where water easily forms channels across the property (waterways, streams, diversion ditches)
- areas where the soil is left bare after crop harvest or during the early growth period of new plantings, especially during the rainy season or windy periods

Conservation Practices for Small Scale Hawaiian Farms

THE FIRST STEP IN DETERMINING HOW YOU CAN CONTRIBUTE TO WATERSHED HEALTH IS TO SURVEY YOUR FARM. One way to help identify potential sources of water pollution around your farm is to make a map showing its fields, buildings, roads, streams, uncultivated areas, and other features. Next prepare a list of the problems that you would like to solve with conservation practices. For example:

- Are gullies forming in fields?
- Is runoff from your farm into waterways muddy? Is it carrying excess nutrients from fertilizer or animal waste?
- **Is runoff from your farm affecting your neighbor's farm?**
- Do you see areas where sediment has built up at the lower parts of fields?
- Are your plants healthy and productive?
- Do you see wildlife on your farm?



When evaluating erosion control practices you should also consider the effects a planned practice may have on a neighboring field or farm. Local grading ordinances that apply to farming and are designed to protect off-site areas from flooding and sedimentation. Farmers are responsible for the quality of the water leaving their property. You can be penalized if the water is excessively turbid (murky) or if your downstream **neighbor's property is damaged. Fortunately, there are** conservation practices to address nearly any environmental problem that you can identify on your farm. Some of these problems and solutions are described below.

Many of the Natural Resources Conservation Service (NRCS) practices to minimize soil erosion and water pollution described in this handbook are based on traditional farming methods practiced for centuries by Pacific Island farmers. Information about these and other conservation practices to use on your farm are available free of charge from the NRCS in the form of an electronic field office technical guide (eFOTG), accessible via the Internet or as a written reference publication available at every NRCS Service Center. NRCS Office locations and phone numbers can be found at: <http://www.nrcs.usda.gov/wps/portal/nrcs/main/pia/contact/local/>

Hawaii's Pollution Prevention Information (HAPPI) publications for farmers can get you started assessing your farm. There are 10 HAPPI-Farm publications, including HAPPI-Farm 2: Mapping Your Farm to Identify Pollution Risks, available at:

<http://www.ctahr.hawaii.edu/site/PubList.aspx?key=Hawaii%27s%20Pollution%20Prevention%20Information>

Hawai'i	Hilo Service Center	(808) 933-8381
	Waimea Service Center	(808) 885-6602
	Kealahou Service Center	(808) 322-2484
Kaua'i	Lihue Service Center	(808) 245-9014
Maui	Kahului Service Center	(808) 871-5500
Moloka'i and Lana'i	Hoolehua Service Center	(808) 567-6868
O'ahu	Aiea Service Center	(808) 483-8600

CONSERVATION PRACTICES TO PROTECT HAWAII'S SOIL AND WATER AND IMPROVE FARM PRODUCTIVITY

Careful stewardship must be practiced to avoid land and soil degradation and sustain farmlands, especially in tropical settings such as in Hawai'i. Farmers can reduce erosion and sedimentation by 20 to 90 percent by applying management practices that control the volume and flow rate of runoff water, keep the soil in place, and reduce soil transport. Common erosion-induced degradation concerns that can be addressed by conservation practices are summarized in Table 1. NRCS practices to address these concerns are also described below. Conservation System Guides for Pacific Basin Farmers and Ranchers for most of these practices are included in Appendix 1 of this publication, and can also be accessed at:

ftp://ftp-fc.sc.egov.usda.gov/HI/pub/technical/conservation_system/ or
<http://www2.ctahr.hawaii.edu/wq/publications/publications.htm>.

PRACTICES TO MINIMIZE EROSION FROM BARE SOIL

To prevent erosion from bare soil, protect the soil surface year round with a thick cover of living plants or with mulch (chopped leaves, small branches, coconut husks, wood chips, etc.) Plant and mulch cover protects the soil surface from the impact of falling rain, enhances infiltration and minimizes as well as slows the speed of runoff. Plant roots help loosen the soil and let water soak into the ground. Plant root systems hold soil particles in place. Consider using the following practices to keep bare soil covered year-round. Practice numbers are in parentheses.

Cover Crops (340) Vegetative cover for bare areas will reduce erosion considerably by cutting down the rate of soil detachment by raindrops. Planting cover crops or green manures is a traditional Pacific Island practice that protects exposed soil and improves soil structure and quality on areas that are fallow and will be replanted. Cover crops that are incorporated into a field prior to replanting can add valuable organic matter and nutrients to the soil. Nitrogen-fixing plants such as "Tropic Sun" Sunhemp (*Crotalaria juncea*) make good cover crops. Cover crops should be chosen from Table B of the Pacific Islands Area Vegetative Guide, available at: http://www.nrcs.usda.gov/Internet/FSE_PLANTMATERIALS/publications/hipmstn14436.pdf

Conservation Covers (327) Conservation covers, or permanent cover crops, are used to protect soil and reduce weeds in areas that are not used for crops such as between fields, in permanent strips on sloping land, and between tree rows in orchards. Consult Table A of the Pacific Islands Area Vegetative Guide for species suitable for conservation covers. Highly disturbed areas that are actively eroding and need stabilization such as eroded stream or channel banks may be best treated with the Critical Area Planting (342) practice.



Onions planted into cowpea residue



Conservation cover under coffee

Conservation Practices for Small Scale Hawaiian Farms

Table 1: SUMMARY OF MAJOR EROSION HAZARDS REQUIRING CONSERVATION ACTIONS

HAZARD CAUSED BY	POTENTIAL DEGRADATION IMPACT	PRINCIPLES UNDERLYING PROTECTIVE ACTIONS	EXAMPLES OF APPROPRIATE ACTIONS
EXPPOSED, BARE SOIL	Excessive runoff, accelerated soil loss rates, decline in soil productivity, damaging lower landscape segments, impairing water quality	Prevent or minimize soil exposure, enhance farm biodiversity	Mulching, recycling crop residue, using minimum tillage and cover crops, incorporating perennial species in designed cropping system
FARMING ON LONG AND STEEP SLOPES	Enhanced, "concentrated runoff" with formation of rills or gullies and possible mass movement	Reduce slope length and steepness, maximize soil surface roughness	Contour farming as beds and furrows, terracing, installing hedge rows, agroforestry in cross-slope configuration, hillside ditches
EXCESSIVE RUNOFF AND FLOWING WATER	Accelerated erosion and gully formation	Minimize soil exposure, maintain sound soil surface conditions to optimize infiltration	Managing slope lengths, using cross-slope live or built barriers, providing safe runoff disposal (grassed) waterways and structures
PHYSICAL AND CHEMICAL RUNOFF LOAD	Non-point source pollution and impairing the quality of receiving estuaries/water bodies	Implement effective measures for runoff control, accurately prescribe and efficiently manage applied agricultural chemicals	Maximizing infiltration, obtaining and using UH-ADSC ¹ recommendations for crop protection and nutrient management to avoid unnecessary excesses of applied fertilizers and pesticides, Integrated Pest Management (IPM)
HEAVY AGRICULTURAL TRAFFIC	Soil disturbance, loosening and enhanced sediment detachment	Select appropriate road design, surface protection measures, and frequency and timing of use	Use "hardy" live surface vegetation, crop residue, or other stabilizing provisions to control sediment production, including detachment by wind
ANIMAL MANAGEMENT	Soil exposure under uncontrolled grazing	Using realistic carrying capacity, optimize year-around pasture production, and benefit from recycled animal waste	Installing fences to ensure prescribed grazing, controlling animal tracks and paths for pasture and water access
RANDOM FARMING ACTIONS BY LAND USERS WITHIN THE WATERSHED	Degradation of watershed, reduced groundwater recharge, loss of soil productivity, off-site sediment impacts on Hawai'i's estuaries	Embrace the traditional ahupua'a system of land management	Organize an "Ahupua'a Users' Association" to advocate, pursue, and monitor collective, neighbor-friendly watershed management practices.

¹University of Hawai'i Agricultural Diagnostic Service Center

Mulching (484) Mulching with organic and inorganic materials can be used to protect the soil surface, improve soil moisture, add nutrients and organic matter to the soil, and smother weeds. Sources of organic mulch include crop residue, chipper waste and compost.

Materials and application methods differ in supporting crop growth, enhancing infiltration and protecting the soil surface



Plastic sheets offer some advantages



Unshredded newspaper is ineffective



Shredded plant material is best

Residue and Tillage Management (329) This practice is similar to mulching but uses plant residue to protect the soil surface from raindrop erosion, add nutrients to the soil, improve soil moisture, and smother weeds. Recycled crop residue provides instant and effective protection against excessive runoff and erosion. Minimizing soil disturbance by planting without tilling is a traditional Pacific Island method to grow food in steep areas while reducing soil erosion.

Tree/Shrub Establishment (612) Establishing woody plants provides long-term erosion control and improved water quality. Tree and shrub canopies reduce rainfall erosion and perennial vegetation stabilizes soil on steep hillsides. Trees and shrubs also help control noxious and invasive species, provide forest products, and improve wildlife habitat on farms. Practice standards for specialized tree/shrub establishment include: Riparian Forest Buffer (391), Alley Cropping (311), Windbreak/Shelterbelt Establishment, (380); Hedgerow Planting (422), Multi-Story Cropping (379), and Silvopasture Establishment (381). Consult Table J of the Pacific Islands Area Vegetative Guide for suitable tree and shrub species.



Tree establishment on the Big Island

PRACTICES TO MINIMIZE SOIL LOSS ON SLOPES

Slope length, steepness and surface roughness affect erosion. Water flows quickly down slopes that are long, smooth, and straight. Water traveling at high speed has power to cut down into the soil, making rills and gullies. Consider using these conservation practices to shorten slope lengths, make slopes more irregular, and slow down rainwater.

Row Arrangement (557) For fields with mild slopes, this practice can help reduce soil erosion as a stand-alone practice or in conjunction with other conservation practices. The practice requires laying out crops in rows to control the length, grade, and direction of water flow and is often called “cross slope farming.”

On steeper slopes a variety of practices can be used to farm across slope (instead of up and down the slope) following the contours of the land. This is called contour farming. Contour farming is a traditional Pacific Island practice used on hillsides to minimize soil erosion. Perennial vegetation planted along the contour can further improve soil stability. Conservation practices for farming across slopes include:

Alley Cropping (311) and Hedgerow Planting (422) To alley crop, rows of trees or shrubs are planted across the slope to provide structural support for crops grown in the space between rows of woody plants. Alley cropping reduces surface water runoff and erosion, improves soil health by increasing utilization and cycling of nutrients, acts as a green manure when nitrogen fixing trees and shrubs are used, decreases offsite movement of nutrients or chemicals, and enhances wildlife and beneficial insect habitat. Hedgerow planting is a similar practice using woody plants or perennial bunchgrasses to delineate contour guidelines.



Alley cropping

Contour Farming for Cropland (330) Conducting all farming activities (plowing, planting, cultivating, and harvesting) across the slope keeps soil in place, allows more water to soak into the soil, and reduces runoff of pollutants (sediment, nutrients, pesticides) from the farm.



Contour Farming

Contour Farming for Orchards (331) This practice of establishing tree crops or orchards in a contour farming system is recommended for steep slopes where minimal soil disturbance is necessary to minimize soil loss. Farming activities are less intensive than for contour farming for cropland, and therefore, result in less soil disturbance. The benefits of this practice are similar to those for Contour Farming for Cropland (330).

Hillside Ditch (423) Hillside ditches are a traditional Pacific Island practice of building shallow ditches along the contour of slopes where crops are planted to protect the land from erosion. These ditches break long slopes into shorter segments to slow the flow of rainwater as it moves downhill and to direct runoff into stable areas. Hillside ditches can be built with or without a vegetative barrier to aid in slope stabilization and sediment capture

Terrace (600) Terraces are earth embankments, or a combination of ridges and channels, constructed across the slope of a field to reduce erosion by reducing slope length and to retain runoff for moisture conservation. Rock Barriers (555) and Vegetative Barriers (601) can be incorporated into the terrace design.

Rock Barrier (555) A rock barrier is a rock retaining wall constructed across the slope to form and support a bench terrace that will control the flow of water and check erosion on sloping land. Rock barriers are generally used on steep slopes where the effectiveness of less intensive measures for soil and water conservation are inadequate.

Vegetative Barrier (601) Vegetative barriers are permanent strips of stiff, dense grasses grown across a slope or across a permanent drainage way. In a contour farming system they can be used on milder slopes to create flat terrace-like structures that stabilize slopes, reduce erosion, and retain runoff in the field; or they can be planted at a low gradient to guide concentrated runoff from the field.

An additional practice to minimize soil loss from slopes:

Residue and Tillage Management (329) This practice of using plant residue to protect the soil surface reduces erosion, adds nutrients to the soil, improves soil moisture, and smothers weeds. Minimizing soil disturbance by planting without tilling is a traditional Pacific Island method to grow food in steep areas that further reduces soil erosion.

ADDRESSING SEDIMENT, NUTRIENT, AND PESTICIDE RUNOFF FROM FIELDS

The most widespread source of agricultural water pollution is soil that is washed off fields and pastures. Rainwater carries soil particles (sediment) and can carry them off farms into streams. In addition, other pollutants like fertilizers and pesticides are often attached to the soil particles and wash into surface waters. While the conservation practices discussed earlier serve to reduce erosion in the field, the practices discussed immediately below seek to capture and remove the sediment as near the field as possible and improve the water quality of the storm runoff leaving the farm.



Integrated Pest Management (595) Integrated pest management (IPM) is a site-specific combination of pest prevention, pest avoidance, pest monitoring, and pest suppression strategies. IPM encourages using natural barriers to pest movement and pesticide drift, limits pesticide use, and manages necessary applications to minimize pesticide movement from fields.

Pest monitoring for IPM

Nutrient Management (590) Nutrient management is managing the amount, placement, and timing of fertilizer, cover crops, compost, and manure application on crop needs. By applying only what is needed to optimize crop growth farmers can reduce expenses and protect surface and ground water from nutrient pollution.

Residue and Tillage Management (329) Protecting the soil year round with plant residue and minimizing soil disturbance through no-till planting practices reduces pollutant runoff.

Field Border (386) A field border is a strip of permanent vegetation established at the edge or around the perimeter of a field to disperse runoff and reduce discharge of sediment, nutrients, pesticides, and other contaminants from a field. A Filter Strip (393) located between a field border and an area such as a gulch can be used to provide additional pollutant capture before the runoff exits the farm.

Filter Strip (393) A filter strip is a band of herbaceous vegetation that is planted between farmed areas, such as cultivated fields and pastures, and environmentally sensitive areas to remove sediment, nutrients, pesticides, and other contaminants from overland flow. Filter strips are most effective when flow depths are low and the flow is uniformly spread over a wide area.

ANIMAL MANAGEMENT PRACTICES

Grazing animals can cause erosion in pastures, streams, and gulches. Animal activity in streams and gulches can also increase nutrients and pathogens in surface waters. Animals can also eat all the plant cover leaving the soil bare. Consider using these conservation practices to help protect stream banks from livestock damage, keep runoff from pastures out of waterways, and improve pastures.

For agronomic diagnosis and recommendations on soil nutrient management for productive farms and healthy crops, the Cooperative Extension Service (CES) of the **University of Hawai'i's** College of Tropical Agriculture and Human Resources (CTAHR) is readily accessible to assist you. CES has offices in all counties and extension agents can be called for assistance. CTAHR's Agricultural Diagnostic Services Center (ADSC) provides a comprehensive set of analyses and recommendations at nominal cost. The most highly recommended first step is to test your soil. Necessary steps are explained in the ADSC website.

<http://www.ctahr.hawaii.edu/site/adsc.aspx>



Gully erosion on Molokai, initially induced by uncontrolled grazing

Fence (382) Fences are used to protect crops from damage, manage grazing animals, and to keep livestock away from certain areas on the farm. Fences can prevent livestock from: polluting streams; causing erosion from stream banks and other heavily used areas; damaging crops; and damaging sensitive resources (streams, endangered plants and animals, drinking wells).

Prescribed Grazing (528) Prescribed grazing manages the harvest of vegetation with grazing and browsing animals. It is done by dividing the farm into paddocks with fencing, and then moving the animals through the paddocks for a short period of time. The goal is to make the best use of available pasture by matching the grazing demand of livestock with the vegetative yield of the grazing land. Prescribed grazing can improve forage quality, reduce soil erosion, keep animal wastes out of waterways, and control weeds.



Rotational grazing proved effective in maintaining land and animal productivity and protecting against soil erosion on Hawai'i Island

Animal Trails and Walkways (575) This practice establishes lanes or travel ways that facilitate animal movement. Established trails and walkways: provide or improve access to forage, water, working and handling facilities, and shelter; improve grazing efficiency and distribution; and protect ecologically sensitive, erosive, and potentially erosive sites.

Watering Facility (614) A watering facility is a permanent or portable watering system to provide livestock or wildlife with an acceptable quantity and quality of drinking water. Watering facilities are effective at keeping livestock out of streams and other environmentally sensitive areas.

Heavy Use Area Protection (561) Heavy use area protection is the stabilization of areas frequently and intensively used by people, animals or vehicles by establishing vegetative cover, surfacing with suitable materials (mulch, ground coral, gravel, asphalt or concrete), and installing needed structures. Heavy use area protection reduces dust, puddles and washouts and provides a stable, non-eroding surface for high-use areas such as watering facilities, under shade trees, or along animal trails and walkways. Filter strips (393) can be used to clean dirty water draining downhill from heavy use areas.

Range Planting (550) Range planting establishes adapted perennial or self-sustaining vegetation such as grasses, forbs, legumes, shrubs and trees. In degraded pastures, range planting can improve the vegetation community improving forage and making the pasture more resistant to erosion. Range planting can also be used to plant trees to provide an attractive resting area for cattle.

Forage and Biomass Planting (512) Forest and biomass planting uses adapted and compatible species, varieties, or cultivars of herbaceous species suitable for pasture, hay, or biomass production. Forage and biomass planting improves the forage quality and erosion resistance of pastures by establishing plants to provide better ground cover and greater root mass.

PRACTICES DESIGNED FOR HEAVY USE AREAS

Some areas on the farm get so much heavy traffic and use that they need additional work to help prevent erosion. Part of the solution is to move (or divert) clean water away from these heavily used areas. The second part of the solution is to strengthen these areas (with plants, mulch, gravel, etc.) to protect them from erosion.

Access Roads (560) Access Roads are fixed travel ways for equipment and vehicles to move crops, animals, supplies, and equipment around a farm. Farm roads can be a major source of sediment if not engineered correctly. Roads which are constructed up and down the slope often become the main drainage ways for runoff from the fields and erode heavily during storms. The Access Roads conservation practice can be used to plan and locate farm roads to be less susceptible to erosion. The conservation practice can also be used to modify existing roads to include drainage elements, such as water bars, to take runoff off of the road and into roadside ditches. The conservation practice can also assist with surfacing or paving of farm roads.



Roads constructed up and down the slope and without proper drainage features carry large volumes of runoff during storm events.



Proper grading, installation of water bars, and vegetating road side ditches help manage runoff and reduce sediment.

Heavy Use Area Protection (561) Heavy use area protection is the stabilization of areas frequently and intensively used by people, animals or vehicles by establishing vegetative cover, surfacing with suitable materials (mulch, ground coral, gravel, asphalt or concrete), and installing needed structures. Heavy use area protection reduces dust, puddles and washouts and provides a stable, non-eroding surface for high-use areas.

Roof Runoff Structure (558) Roof runoff structures are simple gutters, downspouts, and outlets to collect rain from roofs. Roof runoff structures keep roof rainwater away from buildings and other areas on the farm to prevent ponding or flooding farm buildings, prevent undercutting of foundations, prevent rainwater from flowing into animal shelters and pens, and keep rain water from carrying animal wastes, agrichemicals, and other pollutants into surface and ground waters. Roof runoff structures can also be used to collect rainwater for livestock and irrigation use.

COUNTERING EXCESSIVE RUNOFF AND FLOWING WATER

In areas on the land where water runs seasonally or year round (drainage ditches, seasonal and year-round streams), you may need to strengthen the waterway lining to be sure stream and channel erosion is prevented. NRCS professionals can calculate water volume and velocity and recommend long-lasting channel linings for waterways on your farm. Grassed waterways can usually handle smaller amounts of slow moving water. Stone or concrete linings are often needed for larger volumes or higher velocities of water.

Grassed waterway (412) A grassed waterway is a natural or man-made drainage ditch that is carefully shaped or graded and planted with strongly rooted vegetation to carry water at a non-erosive velocity across a farm or down a slope during a heavy rain. Grassed waterways prevent rills or channels forming in the soil, reduce gully erosion, and serve as an outlet for hillside ditches, diversions, and terraces. The grass lining of the waterway can also trap sediment and improve the quality of water leaving a field. In areas where use by humans or animals makes using vegetation cover unsuitable or in areas where highly erosive soils or other climatic conditions make using vegetation only unsuitable, consider a Lined Waterway or Outlet (468).

Vegetative Barrier (601) Vegetative Barriers are permanent strips of stiff, dense vegetation established along the general contour of slopes or across concentrated flow areas such as gullies or grassed waterways. Vegetative barriers are used to slow or redirect flowing water, reduce soil erosion, reduce ephemeral gully erosion, and trap sediment.



Grassed waterway in contour orchard



Grassed waterway with land shaping to left

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Page 13	Road with planning	O'ahu Resource Conservation District
Page 14	Grassed Waterways	Thomas Esgate
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Appendix 1
Conservation System Guides for Pacific Basin Farmers and
Ranchers

Access Roads on Pacific Island Farms

USDA NRCS Practice (560)



Rutted roads can damage farm vehicles making it necessary to repair and replace them often.

What is an access road?

Pacific Island farms need travel ways to move crops, livestock, supplies and equipment around the farm. A stable, long-lasting access road can be a major improvement for any farm business. An **access road** may vary from an unsurfaced trail with seasonal access to a year-round, all-weather surfaced roadway.

Why build and improve access roads?

Pacific Island farmers can benefit from stable access roads on their farm. Using this practice can:

- provide a safe, stable route for moving equipment, supplies, crops, and animals.
- reduce expensive long-term road maintenance and labor costs.
- improve farm appearance and quality of life.
- prevent erosion problems.
- keep water bodies clean.

Where are access roads used?

- In farm areas where vehicles must travel

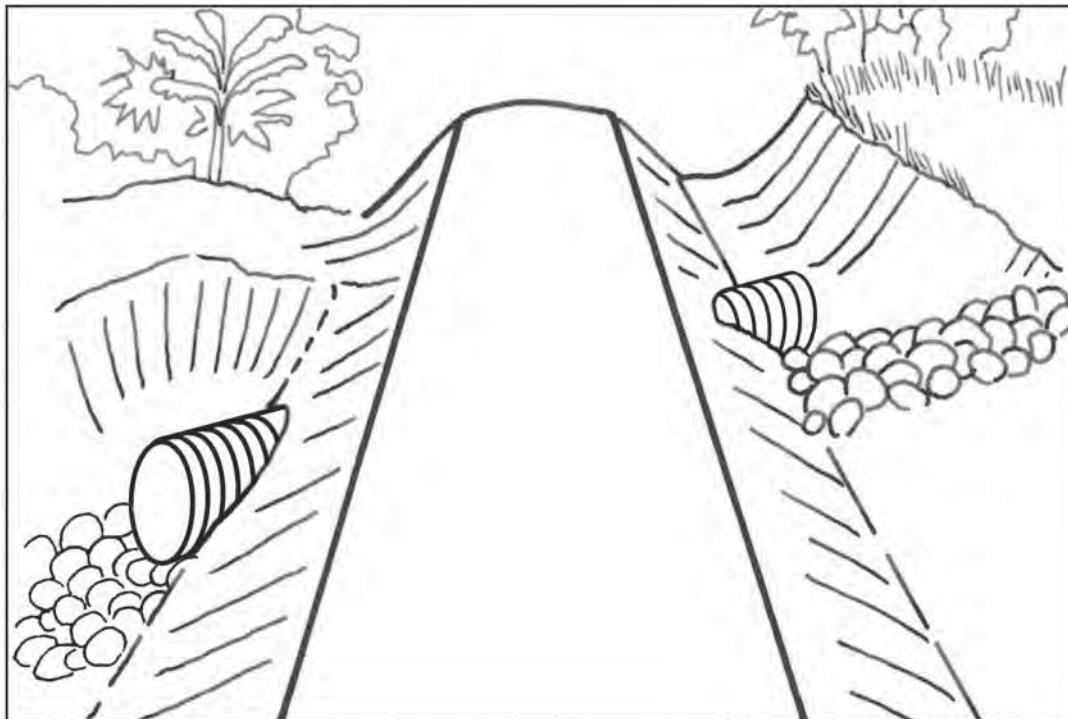
Plan for access roads

Poor access roads can cause many problems for Pacific Island farmers. Rutted roads can damage farm vehicles making it necessary to repair and replace them often. If you are spending valuable time and money to repair sections of the road again and again after heavy rain storms, it may be worthwhile to invest in improving your access roads.

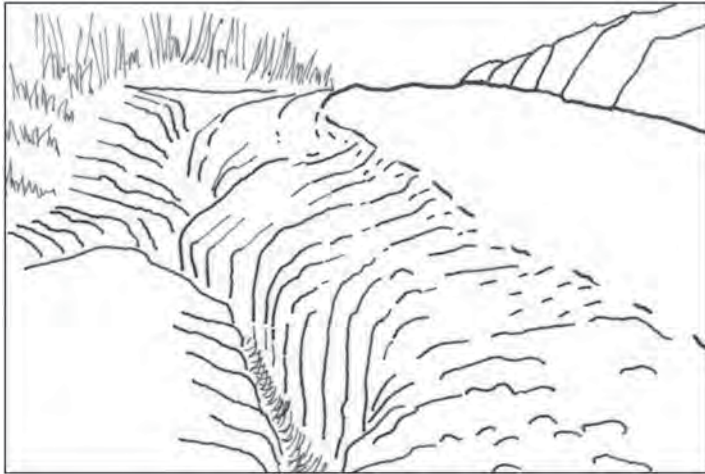
- Consider slopes when laying out roads. Plan and build roads across the slope and stay off steep slopes. Long sections of road going up and down the slope are difficult to drive and keep stable. Avoid them to save time and money on maintenance and repair.
- Consider soils when designing access roads. Learn about the soils your farm roads will cross. For example, heavy clay soils, rocky soils, and wet soils each have different construction considerations to build a durable, long lasting road.
- Consider stream crossings when planning your roads. As much as possible, avoid stream crossings because they are expensive to build and maintain. If they are not built properly, they can wash out, causing expensive damage to property, to water quality, and to fish and wildlife.

Roads that are safe to travel on have a good shape, a stable surface, good drainage, and stable side ditches. A dry road surface provides safer driving conditions.

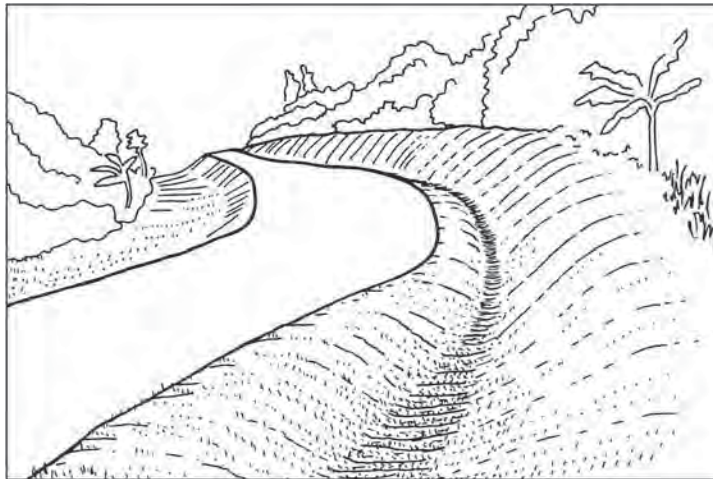
Road Shape: When surface water does not quickly drain off the road, it can lead to washouts, muddy conditions, and potholes. Build roads to drain off the water. Crown the center of the road by making the road higher in the middle and lower on the sides to allow water to quickly run off the road surface.



Roads that are safe to travel on have a good shape, a stable surface, good drainage, and stable side ditches.



The shape of the ditch is important. Narrow V-shaped ditches take less space, but concentrate water into a small area and may cut down into the ground.



Wide flat ditches can spread water out and slow down its speed.

Road Drainage: If needed, use other conservation practices to help divert and drain water off the road surface. Water bars and broad based dips are like speed bumps built at an angle across the road. Use them to move water from the road surface to the road's edge. Open-top culverts are long, box-like channels cut down into the road surface to collect and divert water to the side.

Stable Roadside Ditches: Ditches collect road surface run-off and drain it away from the road. Poorly designed and built ditches can make a bad situation even worse. The shape of the ditch is important. Wide flat ditches can spread water out and slow down its speed. Narrow V-shaped ditches take less space, but concentrate water into a small area and may cut down into the ground. Adjust the shape of the ditch to spread out and slow down water. Don't make ditch side slopes too steep, which can cause erosion and maintenance problems. Discharge water collected from road ditches into natural undisturbed areas with thick plant growth. Some outlet areas may need strengthening with rock or stone.

If your road ditches carry large volumes of storm water, get help from a qualified professional to help design your ditches, culverts and outlets.

Culverts and Stable Outlets: Culverts carry water from one side of a road to the other. They are generally made from corrugated metal, plastic, or concrete. Culverts are used where roads cross drainage ways

(such as a stream or seasonal runoff channel) to keep natural flow patterns and protect wildlife. In other cases, some roads can act like a dam. If the road holds back large volumes of surface runoff, plan to install a culvert to let water get from one side to the other. In both cases, a well sized culvert will prevent your road from being washed out during big storms. Protect the downside end of the culvert from eroding with stone or a plunge pool.

Roads in wet areas: Often wet areas on the farm may be protected wetlands. Avoid building roads through them.

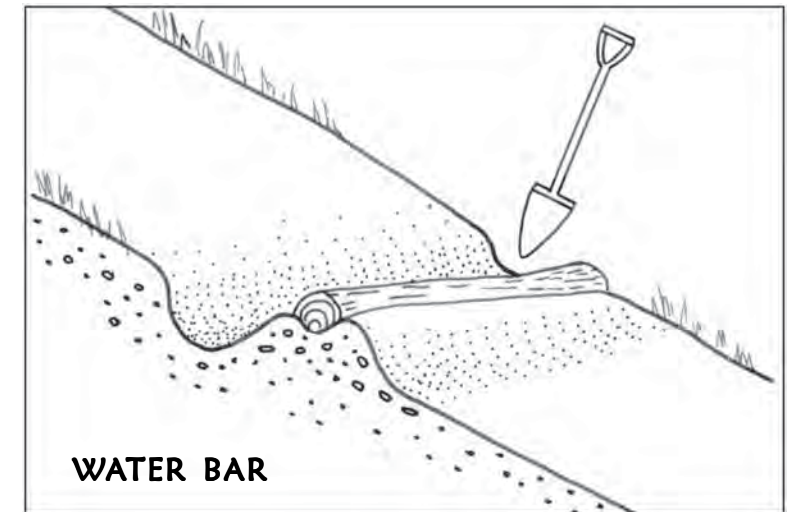
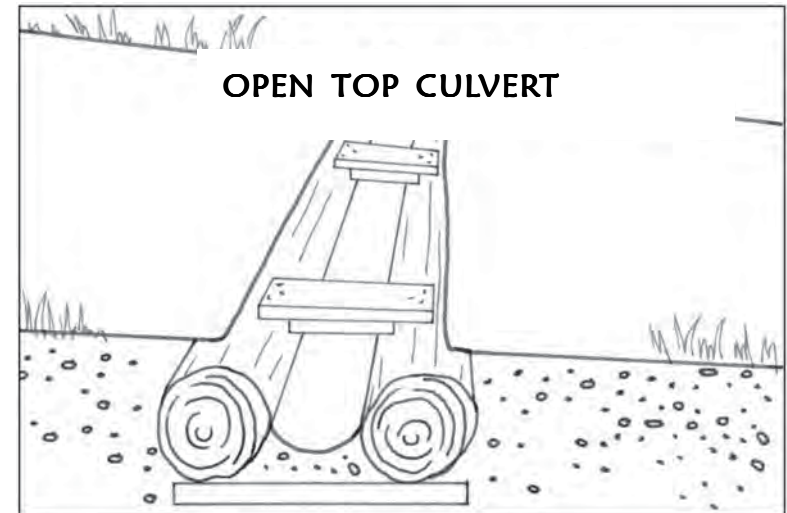
Surfaced roadways: Get help from a qualified professional to design and build surfaced roadways for heavy use.

For the best results, combine **access roads** with other conservation practices:

- **Heavy Use Area Protection (561):** strengthening heavily used areas with mulch, gravel, asphalt, concrete, cement

For assistance to plan, design or construct an access road, contact your local USDA NRCS field office.

Additional information is available from your local USDA Service Center or at www.pb.nrcs.usda.gov and www.hi.nrcs.usda.gov.

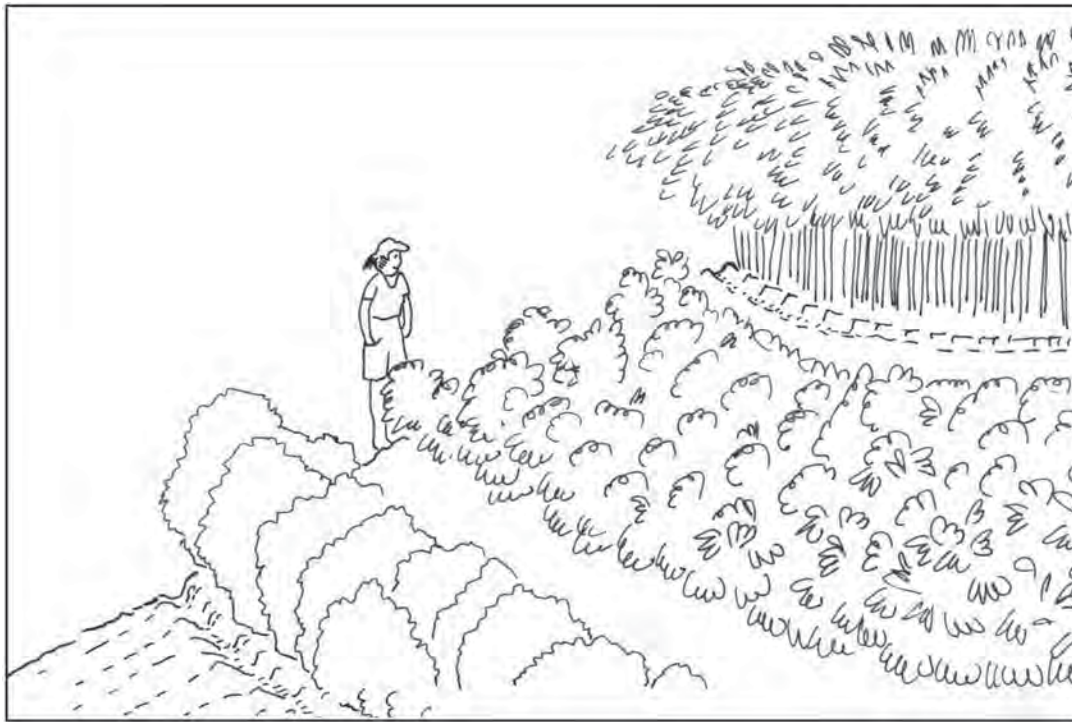


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Alley Cropping on Pacific Island Farms

USDA NRCS Practice (311)



Use alley cropping on your farm to produce many valuable products while protecting soil and conserving water.

What is alley cropping?

When trees or shrubs are planted in a series of rows across the slope (on the contour) and crops are planted between them, it is called **alley cropping**. The shrub/tree rows are called **hedgerows** and the space between where the crops are grown are called **alleys**.

Alley cropping allows Pacific Island farmers to harvest products from their shrubs and trees (such as wood, nuts, cultural and medicinal products) as well as from their main crops (grains, vegetables, fruits, forages, etc.). When nitrogen-fixing shrubs and trees are grown, leaves and shoots from hedgerows can be used as green manure for fertilizing crops and orchards, and as fodder for livestock.

Why use alley cropping?

Pacific Island farmers can benefit from planting trees and shrubs across the slope on their farm. Using this practice can:

- produce a variety of different products (mushrooms, medicinal herbs, nuts, wood, etc.)
 - provide nutrient rich green manure and mulch to fertilize crops and orchards.
 - produce forage and fodder for farm animals.
 - provide in-field protection from wind.
 - protect and improve topsoil. Hedgerows slow down rainwater, filter out soil particles, add
-

organic matter, and let more water soak into the ground.

- reduce erosion.
- provide shade, food and cover for wildlife.

To learn more about protecting your sloping farmland from water damage, read ***Protecting Soil on Pacific Island Farms***.

Where is alley cropping used?

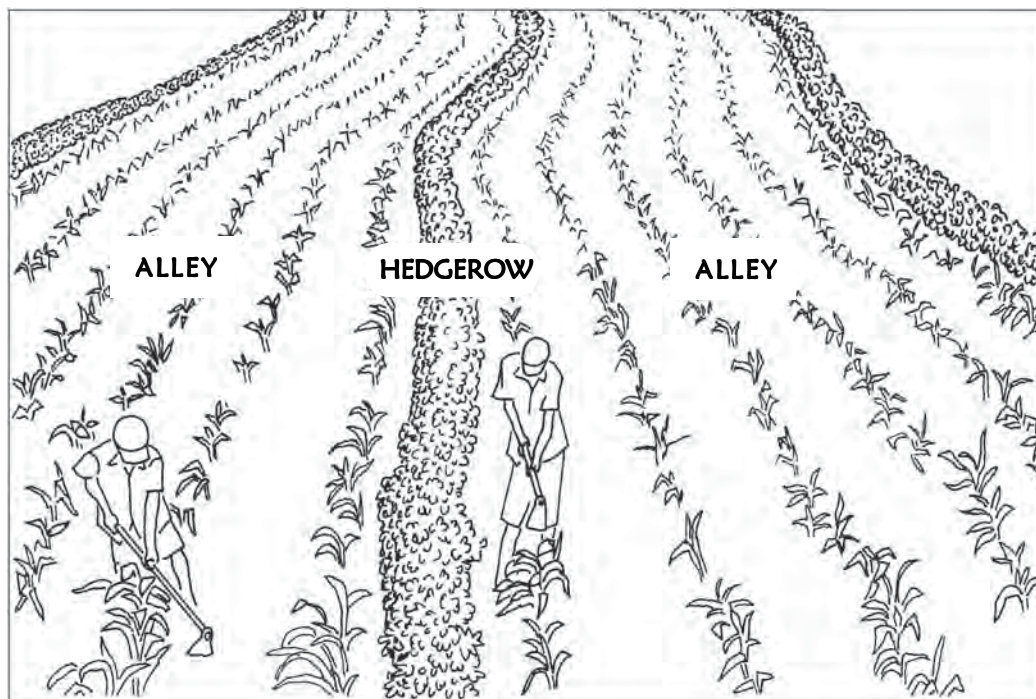
- On sloping fields where crops are grown (includes orchard, row crops, etc.)

Plan your Alley Cropping Hedgerows

Plant Selection

For alley cropping, grow a mix of multipurpose trees and woody bushes that will provide many benefits for your farm. Gliricidia (*Gliricidia sepium*) is often used in Pacific hedgerows because it can be pruned to provide fodder, green manure, and fuel. Some hedgerow trees, such as da'ok or fetau (*Calophyllum inophyllum*), can be grown to serve as windbreaks. Fruit trees and medicinal plants are also grown in hedgerows. Choose a combination of trees and shrubs based on your needs.

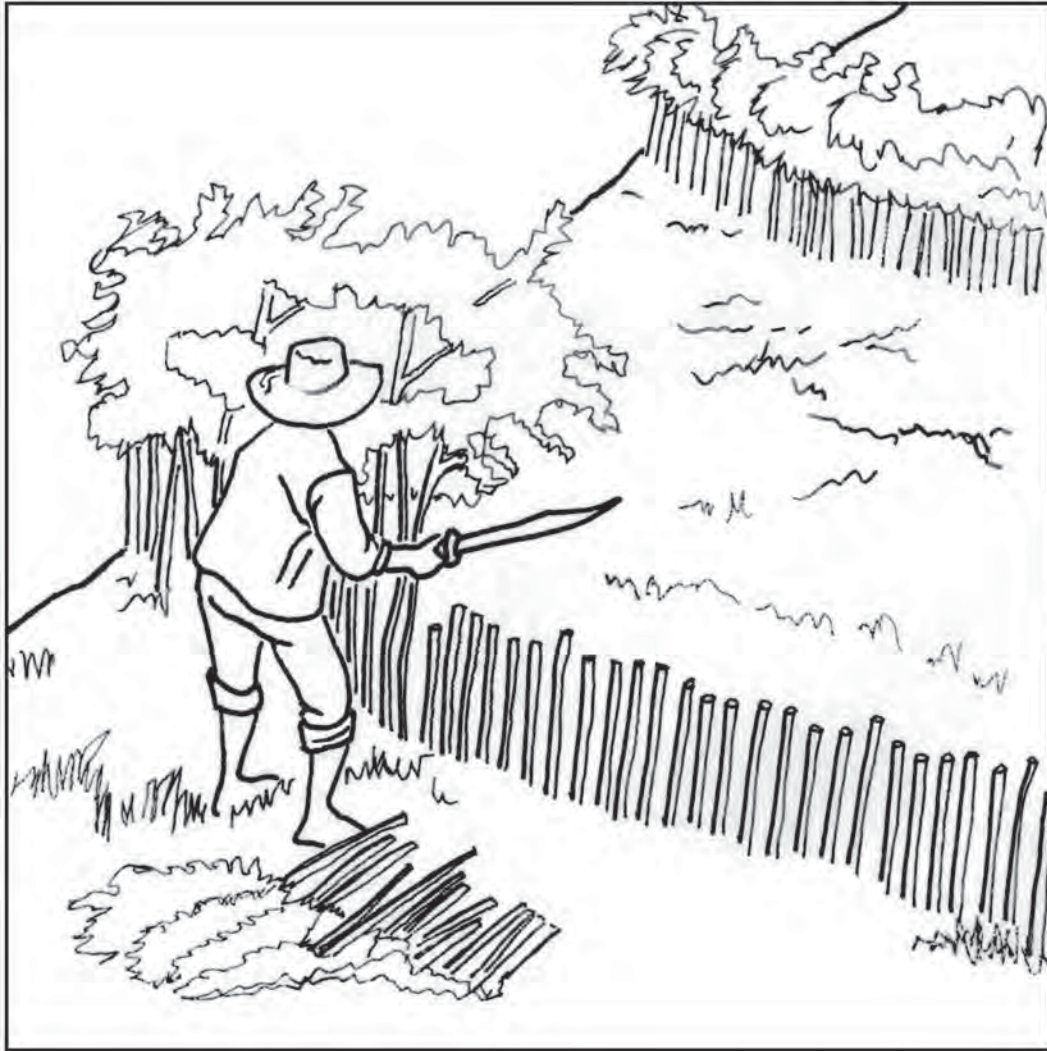
For current lists of suggested alley cropping hedgerow plants suitable for your farm, contact the local office of the Cooperative Extension Service or the local USDA NRCS field office. They can



The shrub and tree rows are called hedgerows. The area between them where crops are grown are called alleys.

Suggested Spacing for Alley Cropping Hedgerows (USDA NRCS Vegetative Barriers)

% Slope of Field	Spacing
10	60 feet (18.3 meters)
20	30 feet (9.1 meters)
30	20 feet (6.1 meters)
40	15 feet (4.6 meters)
50	12 feet (3.7 meters)



Hedgerows can provide nutrient rich green manure and mulch to fertilize crops or to feed the farm animals.

provide you with ideas for plant species, planting rates, planting methods, fertilizer and liming rates.

To get good growth for both your crop and your alley cropping hedgerow:

- pick hedgerow plants that will not compete too much with your crops for water and fertilizer.
- let your hedgerow trees or shrubs grow for at least 12 months before pruning them back to the desired height.
- manage your hedgerow plants so they won't shade your crops.
- don't use hedgerow plants that will attract insects and diseases to your crops.
- don't use hedgerow plants that can escape from the farm and become problem weeds in natural areas or forests.

Plant on the contour

Plant level and across the slope, without any low spots where water can channel and break through. Alley cropping hedgerows should be flat across the slope, no steeper than 1-2% grade. It is important to take time to lay out contour lines to guide you in the field. This is done with simple instruments such as a level or a homemade A-frame. Your local office of the USDA NRCS or the Cooperative Extension Service can help show you how to lay out contour lines.

Hedgerow Tree and Shrub Spacing

The spacing between the trees or shrubs in the hedgerows will be determined by:

- the amount of light needed by the main crops in the alley
- the growth period of the main crops in the alley
- the width and turning areas needed for your machinery
- the importance of protecting your farm's topsoil and controlling erosion.

The steeper the slope of the land, the closer together the hedgerows should be. On very steep slopes, plant hedgerows with at least two rows of trees spaced closely together. Hedgerows should be about six vertical feet apart to protect fields from water damage and reduce soil erosion (see box for suggested spacing).

In a related conservation practice, **hedgerow planting** (422), rows of trees, woody shrubs, or perennial bunch grasses are planted on the land. These rows of plants can be used as a living fence to protect crops, to control animal movement, and to mark field and property borders. Hedgerow plantings can screen out wind, noise and dust. They also provide shade, food and cover for wildlife.

For Pacific Island farms with strong winds, consider planting a **windbreak/shelterbelt** (380). For this conservation practice, rows of trees or shrubs are planted in a special pattern to protect crops from wind damage. The farmer must take many things into account such as wind direction, tree height, row length, and planting density. For technical assistance to design and build a windbreak/shelterbelt, contact your local office of the USDA NRCS.

For the best results, combine **alley cropping** with other conservation practices:

- **Contour Farming for Cropland** (330): carrying out farm operations across the slope
- **Contour Farming for Orchards** (331): carrying out farm operations across the slope
- **Hillside Ditch** (423): digging a small ditch across the slope to divert rainwater
- **Cover Crops** (340): growing crops to plow down and fertilize cash crops
- **Conservation Cover** (327): growing permanent plant cover to protect topsoil and smother weeds

Additional information is available from your local USDA Service Center or at www.pb.nrcs.usda.gov and www.hi.nrcs.usda.gov.

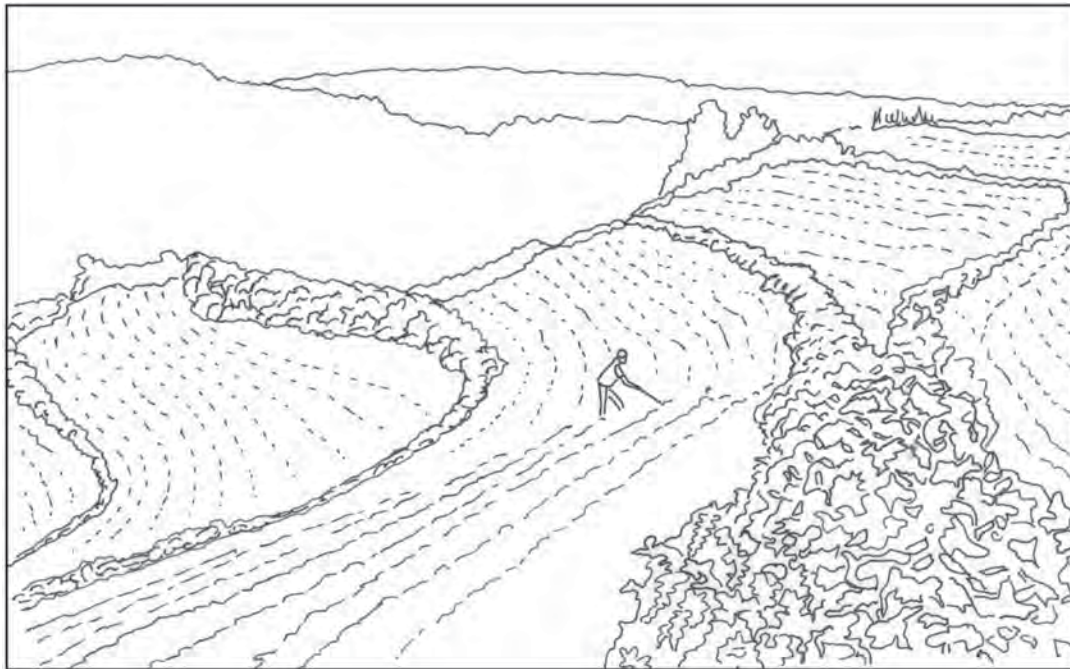


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Contour Farming for Cropland in the Pacific

USDA NRCS Practice (330)



Use contour farming on cropland to conserve water and protect soil on sloping fields.

What is contour farming for cropland?

Contour farming is a traditional Pacific Island practice that is very good for growing food on hillsides. When farmers carry out their farming activities (plowing, planting, cultivating, and harvesting) across the slope instead of up and down the slope, they are using **contour farming**. This is a very old and effective conservation practice used by farmers from around the world.

Why use contour farming on cropland?

Pacific Island farmers can benefit from contour farming on their farm. Using this practice can:

- keep valuable topsoil in place on sloping fields.
- slow water down and let it soak into the soil.
- improve irrigation systems and conserve water.
- reduce labor and make harvesting easier.
- improve the appearance of the farm.

To learn more about protecting your sloping farm land from water damage, read ***Protecting Soil on Pacific Island Farms***.

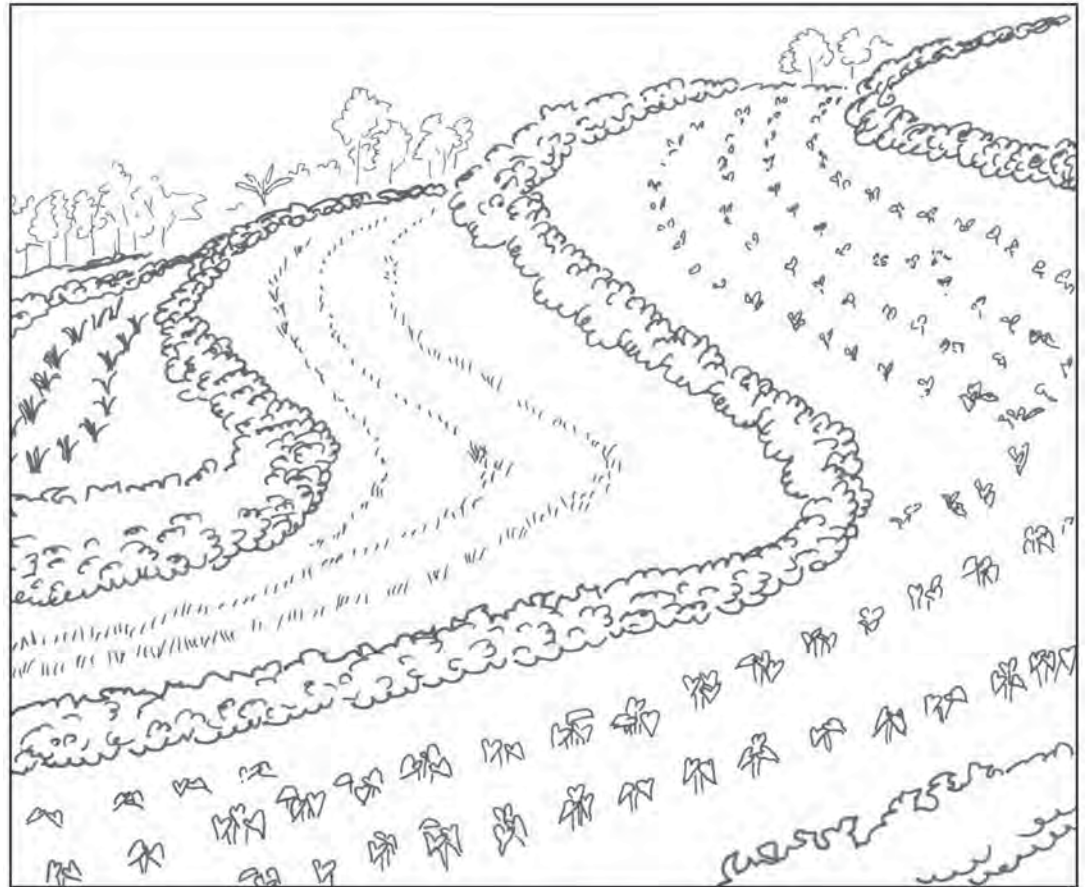
Where is contour farming used?

- On sloping fields where crops are grown
- On sloping fields with vegetable beds

If you grow crops on slopes, you must be very aware of water movement. Be extra careful to protect your fields from water damage. Plan for heavy rain before the rains actually fall. Long, smooth, even slopes speed up runoff water. Fast moving water has a lot of power to cut deep into the land. It can wash soil off your field and damage or destroy your crops. Use conservation practices to shorten slope lengths, make them more irregular, and slow down rainwater.

Start with contour farming

As a farmer, your first step for slowing down rainwater is to determine your field's contour lines. Then plant your crops across the slope or "on the contour". This allows you to do all the land preparation, planting, and harvesting across the slope. Farming across the slope helps to shorten slope lengths, slowing down runoff water so it can soak into the soil.



Contour farming slows water down and lets it soak into the soil.



Combine contour farming with cover cropping and other conservation practices for more soil fertility and slope protection.

It is important to take time to lay out contour lines to guide you in the field. This is done with simple instruments such as a level or a homemade A-frame. Your local office of the USDA NRCS or the Cooperative Extension Service can help show you how to lay out contour lines.

Add on other practices

For more slope protection, combine contour farming on cropland with other practices. You can plant conservation covers, permanent covers, vegetative barriers, and alley cropping hedgerows in strips or rows across the slope. Use mulching and residue management to keep the soil covered. Place slash or plant residue (such as banana stalks and tree trimmings) in strips across the slope to help trap and retain water.

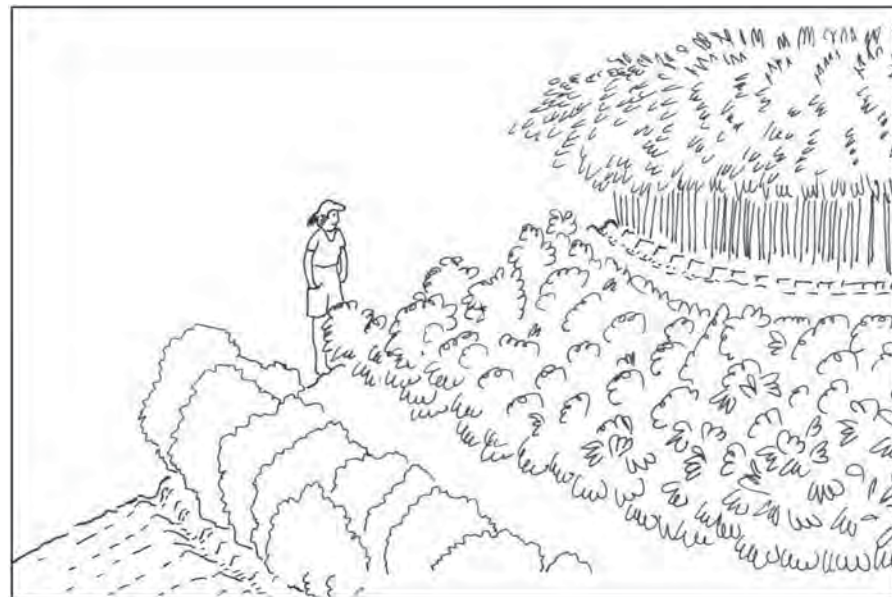
With some basic earth shaping, you can install hillside ditches across the slope. This will shorten the slope length and divert water to a stable area on the farm.

With each additional practice, your farm is better protected from water damage.

For the best results, combine **contour farming** with other conservation practices:

- **Hillside Ditch** (423): digging a small ditch across the slope to divert rainwater
- **Vegetative barriers** (601): growing small strips of stiff plants across the slope
- **Residue Management** (329): leaving slash in the field for soil protection
- **Mulching** (484): bringing in material to cover and protect the soil
- **Cover Crops** (340): growing crops to plow down and fertilize cash crops
- **Alley Cropping** (311) and **Hedgerow Planting** (422): growing hedges of bushes and trees across the slope

Additional information is available from your local USDA Service Center or at www.pb.nrcs.usda.gov and www.hi.nrcs.usda.gov.

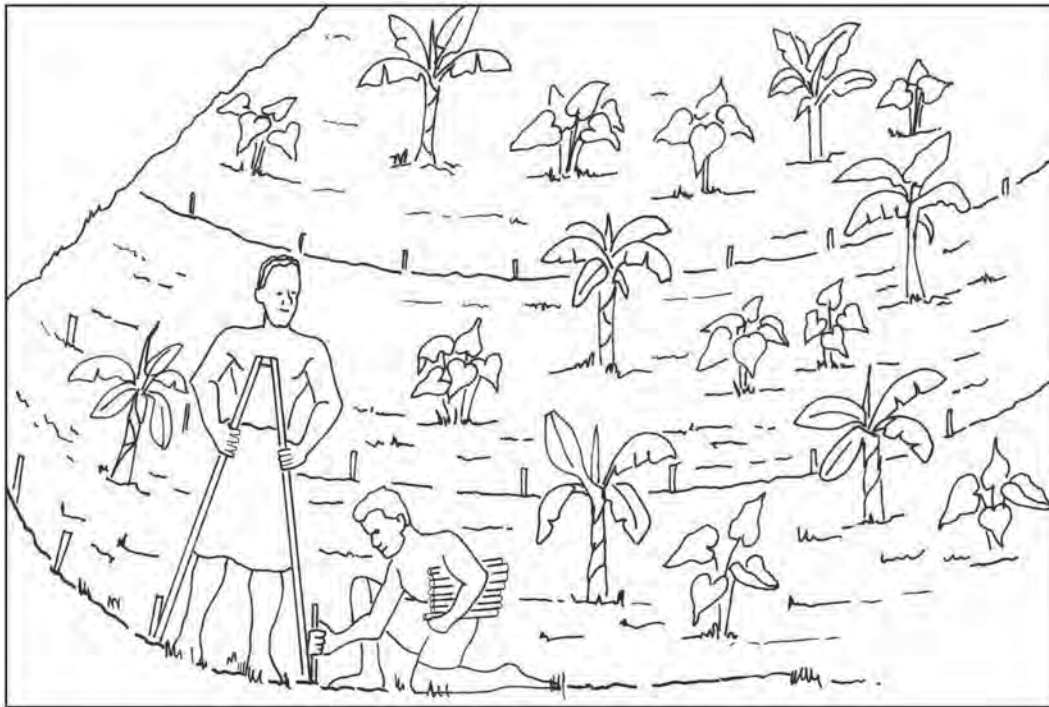


For the best results, combine contour farming with other conservation practices such as alley cropping and contour hedgerows.

Contour Farming

for Orchards in the Pacific

USDA NRCS Practice (331)



In contour farming, tree crops are planted across the slope to conserve water and protect soil. This is done with simple instruments such as a level or a homemade A-frame.

What is contour farming for orchards?

A traditional Pacific Island practice that is very beneficial for growing tree crops on hillsides is to plant the tree rows across the slope instead of up and down the slope. A common name for this practice is **contour farming**. It is a very old and effective conservation practice used by farmers from around the world.

Why plant orchards on the contour?

Pacific Island farmers can benefit from planting their tree crops across the slope on their farm. Using this practice can:

- keep valuable topsoil in place on sloping fields.
- slow water down and let it soak into the soil.
- improve irrigation systems and conserve water.
- reduce labor and make harvesting easier.
- improve the appearance of the farm.

To learn more about protecting your sloping farm land from water damage, read ***Protecting Soil on Pacific Island Farms***.

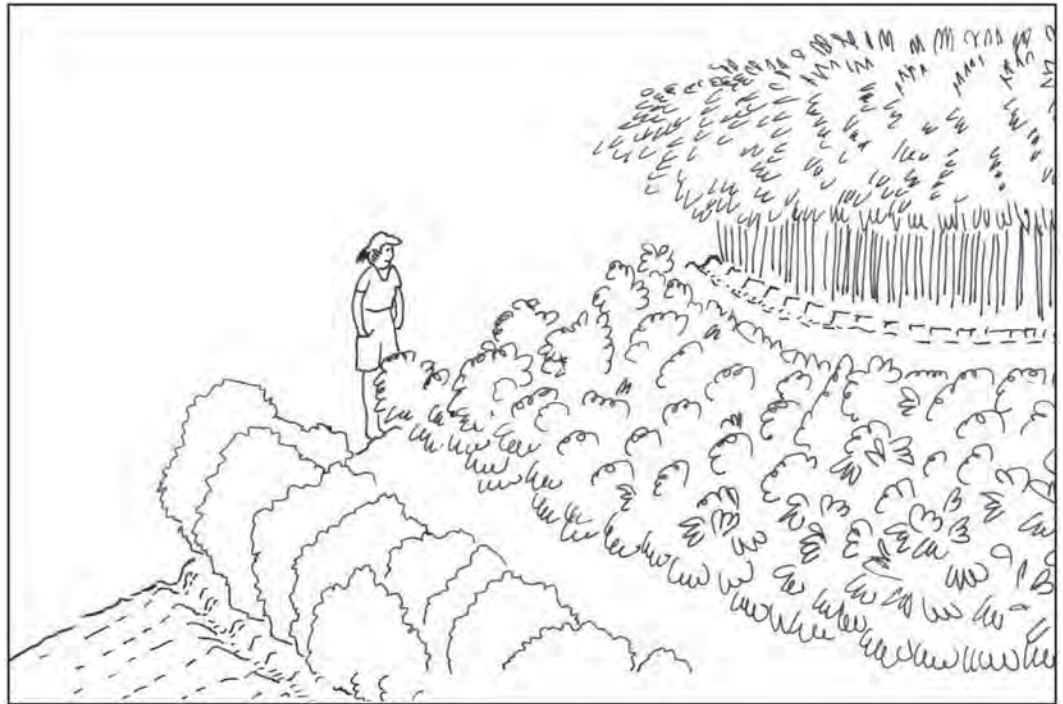
Where is contour farming used?

- On sloping orchards

If you grow trees (for wood, fuel, fruit, nuts, cultural or medicinal uses) on slopes, you should be aware of water movement. Be extra careful to protect your orchard soils from water damage. Plan for heavy rain before the rains actually fall. Long, smooth, even slopes speed up runoff water. Fast moving water has a lot of power to cut deep into the land. It can wash soil off your field and damage or even destroy your trees. Use conservation practices to shorten slope lengths, make them more irregular, and slow down rainwater.

Start with planting on the contour

As a farmer, your first step for slowing down rainwater is to determine your field's contour lines. Then plant your orchard across the slope (or "on the contour"). This allows you to do all the land preparation, planting, and harvesting across the slope. Farming across the slope helps to shorten slope lengths, slowing down runoff water so it can soak into the soil.



Combine contour farming with hedgerows to keep valuable topsoil in place on sloping fields and to produce a variety of different crops.



Combine contour farming with hillside ditches to slow water down and let it soak into the soil.

It is important to take time to lay out contour lines to guide you in the field. This is done with simple instruments such as a level or a homemade A-frame. Your local office of the USDA NRCS or the Cooperative Extension Service can help show you how to lay out contour lines.

Add on other practices

For more slope protection, combine contour orchard farming with other practices. You can plant conservation covers, vegetative barriers, and alley cropping hedgerows in strips or rows across the slope. Use mulching and residue management to keep the soil under the trees covered. Place slash or plant residue (such as banana stalks and tree trimmings) in strips across the slope to help trap and retain water.

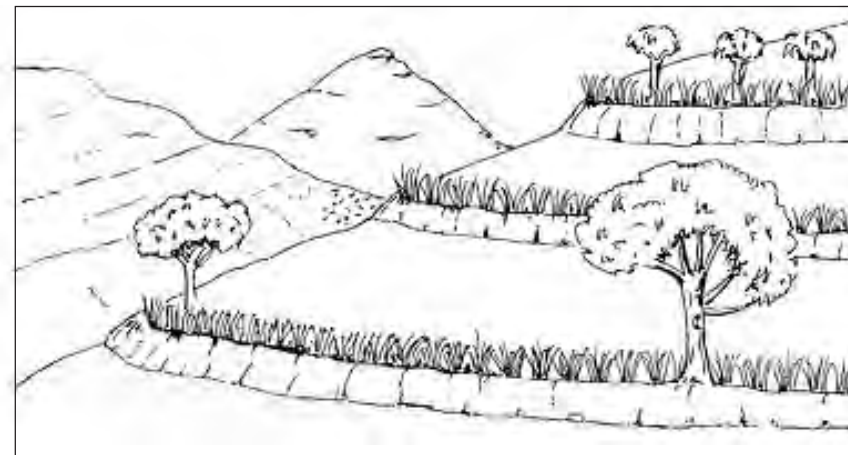
With some basic earth shaping, you can install hillside ditches across the slope. This will shorten the slope length and divert water to a stable area on the farm.

With each additional practice, the farm is better protected from water damage.

For the best results, combine **contour farming** with other conservation practices:

- **Hillside Ditch** (423): digging a small ditch across the slope to divert rainwater
- **Vegetative Barriers** (601): growing small strips of stiff plants across the slope
- **Residue Management** (329): leaving slash in the field for soil protection
- **Mulching** (484): bringing in material to cover and protect the soil
- **Conservation Cover** (327): growing permanent plant cover to protect topsoil and smother weeds
- **Alley Cropping** (311) and **Hedgerow Planting** (422): growing hedges of shrubs and trees across the slope

Additional information is available from your local USDA Service Center or at www.pb.nrcs.usda.gov and www.hi.nrcs.usda.gov.



For the best results, combine contour farming with vegetative barriers and other conservation practices.

Cover Crops and Conservation Covers for Better Harvests

USDA NRCS Practices (340) and (327)



Conservation covers grown under trees can crowd out weeds and improve the soil.

What are cover crops and conservation covers?

Cover cropping is a traditional Pacific Island practice that is very beneficial for the land. Grasses, legumes, or small grains are grown to protect and improve exposed soil. These crops can be planted immediately after harvesting the cash crop and plowed down yearly, or they can be planted and allowed to grow for several years.

- A **cover crop** (or green manure) is a short-term crop that you can kill with herbicide, roll, or plow down into the field to add nutrients for the next crop, to protect the soil surface, and to improve the topsoil. ‘Tropic Sun’ sunnhemp (*Crotalaria juncea*) is a good example.
 - A **conservation cover** (also known as permanent cover crop) is a long-term crop grown year-round to smother weeds and protect topsoil. You can plant them in permanent strips on sloping land and between tree rows in orchards. ‘Tropic Lalo’ paspalum (*Paspalum hieronymii*) is a good example.
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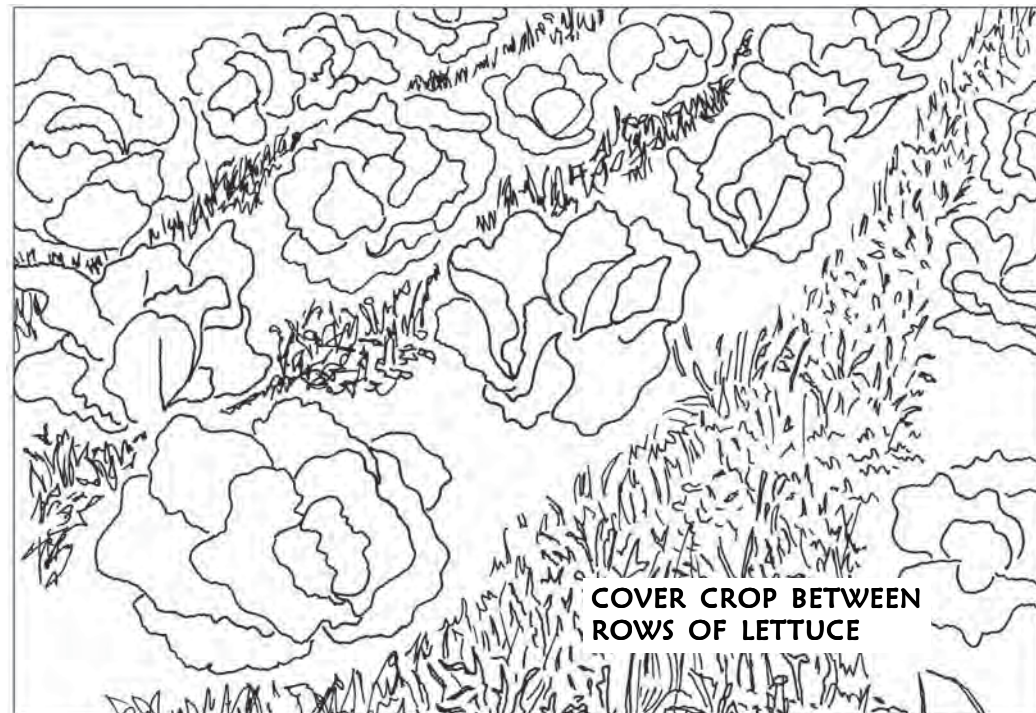
Why use cover crops and conservation covers?

Pacific Island farmers can benefit from cover cropping on their farm. Using this practice can:

- protect topsoil. Cover crops protect the soil surface from raindrops. They help to slow rainwater down. The roots of cover crops hold soil particles in place.
- loosen and improve the soil, allowing more water to soak in and be conserved.
- increase organic matter in the soil.
- fertilize the cash crop to increase the harvest (if a nitrogen fixing cover crop such as a legume is grown).
- suppress the growth of weeds.
- reduce plant diseases, insect pests, and soil nematodes.

Where and when are cover crops and conservation covers used?

- Between rows in crops
- Under fruit and other trees
- In fields with heavy infestations of plant diseases and pests such as nematodes
- Early in the growing season when new crops are still small and filling in
- Between growing seasons when fields are left unplanted



Grow cover crops and conservation covers between rows in crops, especially early in the growing season when crops are still small and filling in. They can also help control plant diseases and pests.



'Tropic Sun' sunnhemp
(*Crotalaria juncea*)

Plan for your cover crops and conservation covers

To get good growth for both your crop and your cover crop:

- pick a cover crop that will not compete with your cash crop for water and soil nutrients.
- be sure your cover crop won't shade out your cash crop.
- be sure the cover crop won't attract insects and diseases that will attack your cash crop.
- break disease cycles by growing non-legume cover crops (such as grasses or small grains) in some years.
- don't use cover crops that can escape from the farm and become problem weeds in natural areas or forests.

For a **cover crop**, choose a plant that:

- fixes nitrogen (legume) or other plant nutrients.
- grows very quickly and produces a lot of tender leaf growth.
- decomposes and releases nutrients quickly when plowed down.

To improve **soil quality** and **residue management**, choose a plant that:

- has a thick, stiff stem yet can be cut or mowed without a problem.
- decomposes more slowly.

For a **conservation cover**, grown in permanent strips between cropland fields and under trees in orchards, choose a plant that:

- does not grow too tall and shades out the cash crop.
- does not twine or wrap around trees.
- grows well under shade.
- crowds out weeds.
- can handle light foot traffic from animals or machinery.

For current lists of suggested cover crop and conservation cover plants suitable for your farm, contact the local office of the Cooperative Extension Service or the local USDA NRCS field office. They can provide you with ideas for plant species, planting rates, planting methods, fertilizer and liming rates.

For the best results, combine **cover crop** (340) and **conservation covers** (327) with other conservation practices:

- **Vegetative Barrier** (601): growing small strips of stiff plants across the slope
- **Residue Management** (329): leaving slash in the field for soil protection
- **Nutrient Management** (590): soil and plant testing to decide how much fertilizer to use
- **Contour Farming for Cropland** (330): carrying out farm operations across the slope
- **Contour Farming for Orchards** (331): carrying out farm operations across the slope
- **Alley Cropping** (311) and **Hedgerow Planting** (422): growing hedges of shrubs and trees across the slope

Additional information is available from your local USDA Service Center or at www.pb.nrcs.usda.gov and www.hi.nrcs.usda.gov.



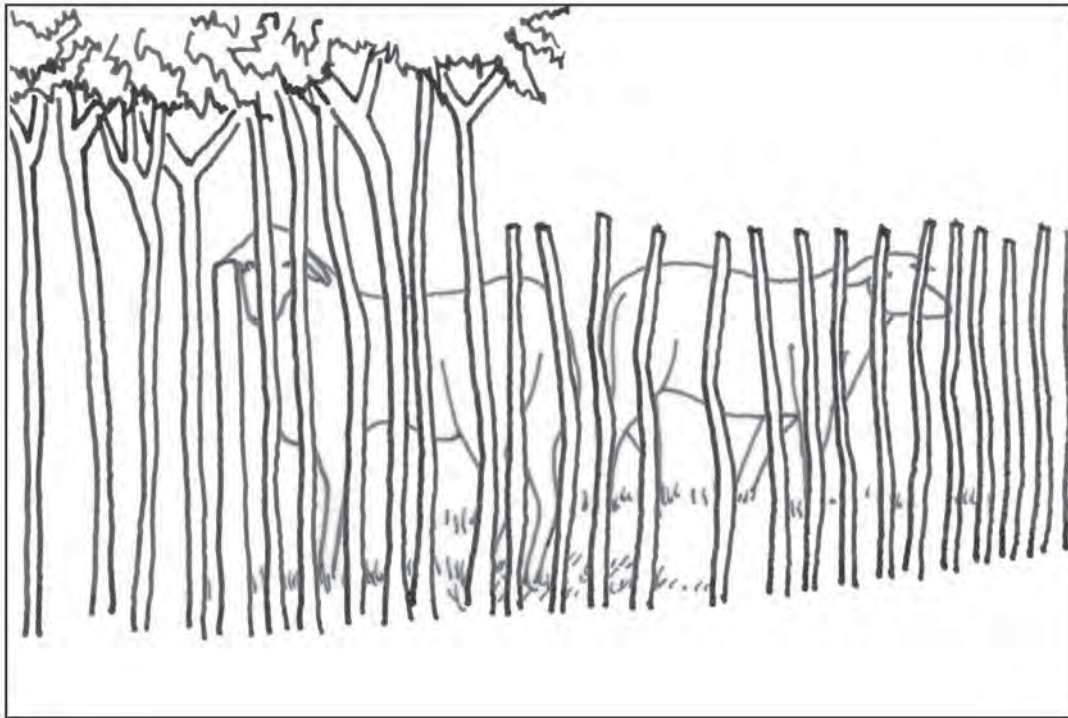
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Fencing

on Pacific Island Farms

USDA NRCS Practice (382)



Use fencing to protect crops from damage, to manage grazing animals, and to keep livestock away from certain areas of the farm.

What is fencing?

Pacific Island farmers often use **fencing** to protect crops from damage, to manage grazing animals, and to keep livestock away from certain areas on the farm.

Why use fencing?

Pacific Island farmers can benefit from using fencing on their farm. Using this practice can:

- manage the location of grazing livestock in a pasture (with prescribed grazing).
 - prevent livestock from polluting streams (with their manure and urine).
 - prevent livestock from causing erosion (on streambanks from their hooves).
 - prevent animals (deer, pigs, etc.) from grazing and trampling on croplands and orchards.
 - keep predators from attacking your livestock.
 - keep people and livestock out of danger (away from highways, steep slopes, poisonous plants).
 - protect conservation areas on the farm (streams, endangered plants and animals, drinking wells).
-

Types of Fencing

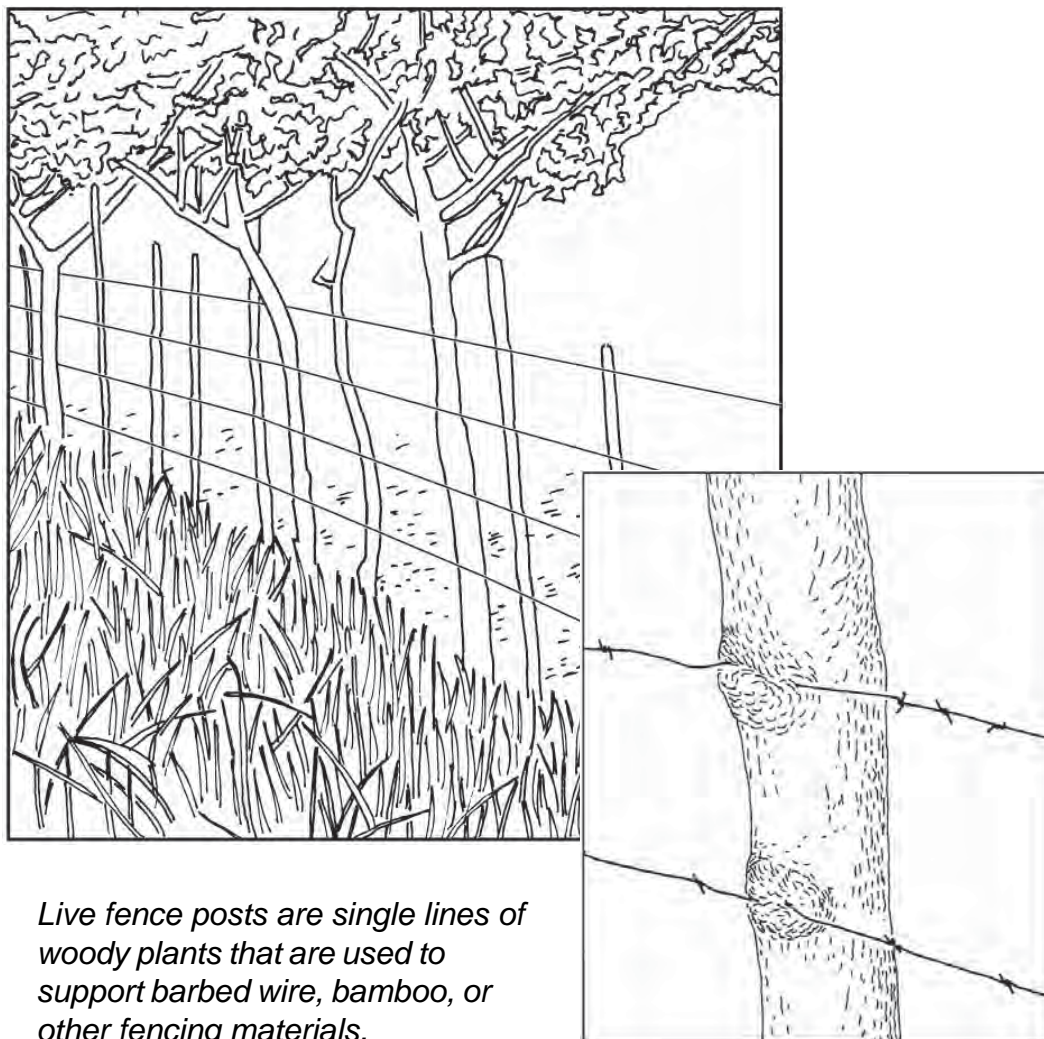
The most common types of fences used by Pacific Island farmers are living fences (where woody shrubs and plants are grown), standard wire fencing (made with barbed, smooth, or woven wire), and electric fencing (made with wire with an electric current running through it).

Living fences: There are two types of live fence systems.

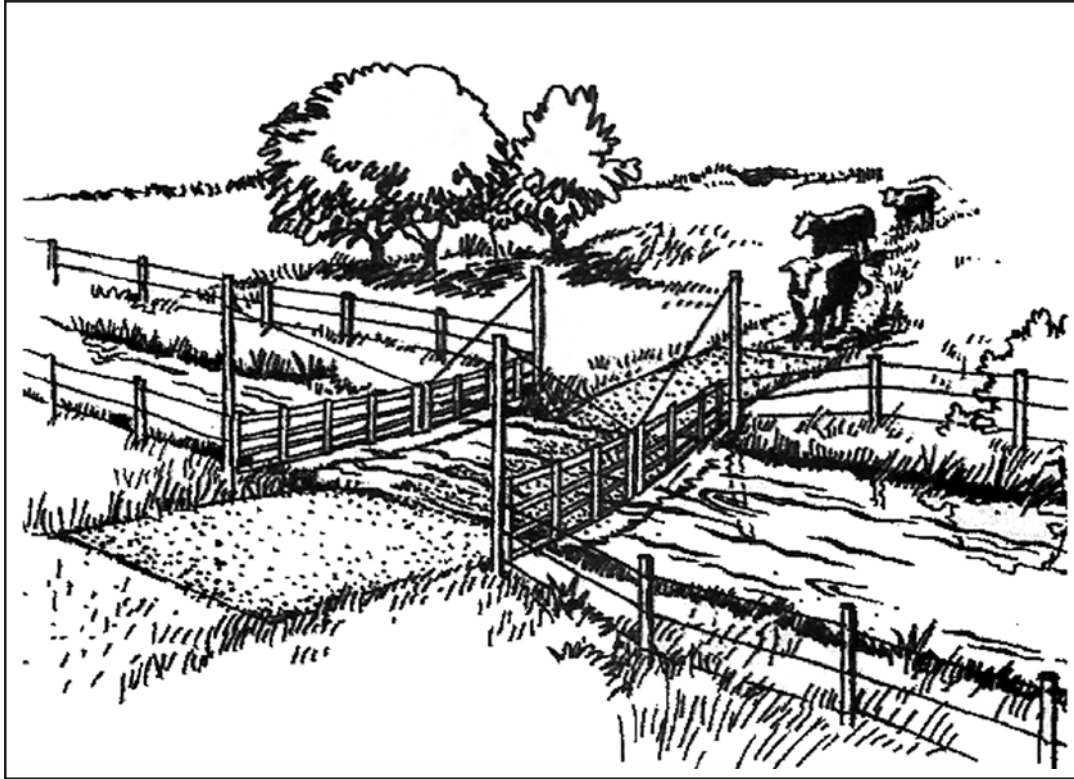
(1) Live fence posts: single lines of woody plants are used to support barbed wire, bamboo, or other fencing materials.

(2) Hedgerows: thick, densely-spaced rows of woody shrubs and plants are grown to provide a barrier for animals or humans.

Living fences are beneficial to plant along streams. Farm animals can damage streams by eating down the plants along the stream's edge, leaving nothing to hold the soil. Their hooves can trample the ground, leaving bare spots that wash soil downstream. They can contaminate the water with their manure and urine. Fencing keeps farm animals from damaging streams. Living fences can be easily



Live fence posts are single lines of woody plants that are used to support barbed wire, bamboo, or other fencing materials.



One use of fencing is to prevent livestock from polluting streams and causing erosion.

grown along streams and will help keep water clean and cool. In addition, living fences can provide fuel wood, high quality forage for livestock, nutrient-rich mulch, food, future fencing material, as well as erosion control and land stabilization. *Gliricidia* (*Gliricidia sepium*) is often grown as a living fence.

Standard wire fence: Strands of barbed, smooth, and woven wire are attached to wooden or metal posts to make these common fences. Farmers use many different combinations of wire, post materials, and fence heights.

Some Pacific Island farmers have problems with wildlife eating their crops. There are many types of fences suitable for controlling wildlife. One example is an 8 foot (2.5 meters) high woven wire fence topped with 2 strands of barbed or smooth wire. This fence keeps out Mouflon sheep, Axis deer, and feral goats. Add a strand of barbed wire at the base to control feral pigs.

Electric Fence: Using a small power source (battery or solar), an electric current is run through wire fencing to shock livestock or predators away. These fences don't have to be as strong as barbed wire because animals learn to be afraid of them. There are many forms of portable electric fencing available.

Temporary, portable electric fencing is useful for **prescribed grazing** systems. This type of grazing is done by dividing the farm into paddocks with fencing, and then moving livestock through the paddocks to graze for a short period of time (1-14 days). This method of grazing avoids build up of manure and urine and often makes manure management much easier. It also helps the farmer to control animal traffic. Areas near the water and mineral sources, under shade trees, and along trails and walkways tend to get damaged by animal traffic. By moving water sources and changing fencing location, these animal traffic patterns can be changed.

Your local NRCS Field office can provide information that will help you design and install the right kind of fence to meet your needs.

For the best results, combine **fencing** with other conservation practices:

- **Prescribed Grazing** (528): use grazing animals to control plant growth
- **Hedgerow Planting** (422): growing hedges of bushes and trees

Additional information is available from your local USDA Service Center or at www.pb.nrcs.usda.gov and www.hi.nrcs.usda.gov.



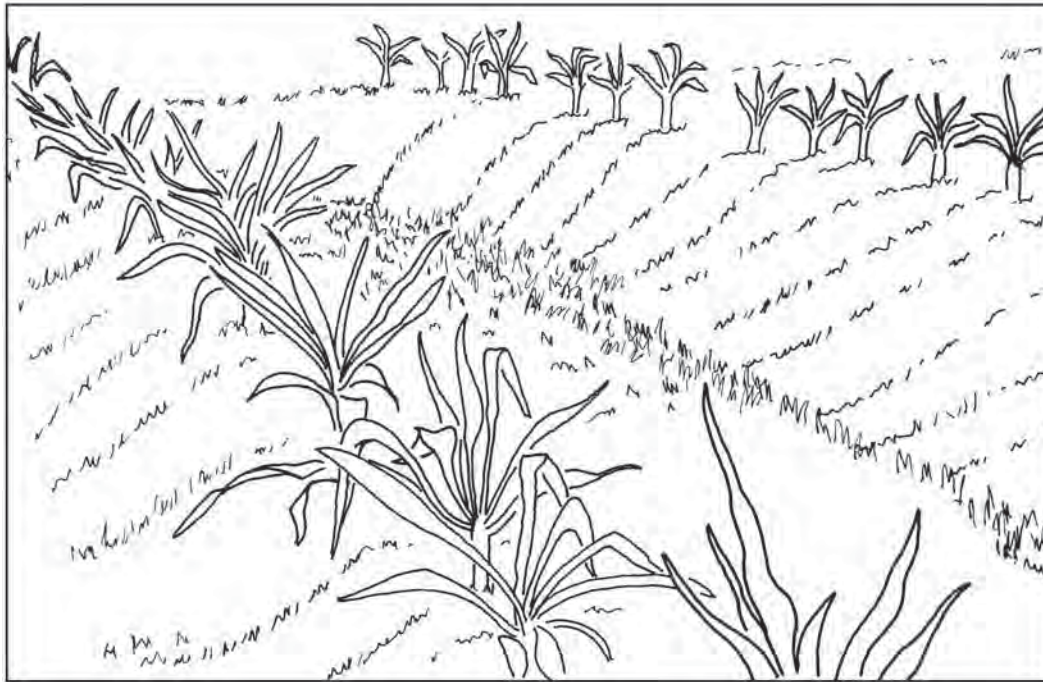
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Grassed Waterways

for Pacific Island Farms

USDA NRCS Practice (412)



Build grassed waterways on your farm to carry water across fields and down steep slopes. They also serve as an outlet for roof runoff structures and hillside ditches.

What is a grassed waterway?

A **grassed waterway** is a natural or man-made drainage ditch that is carefully shaped and planted with strong rooted grass to carry water across a farm or down a slope during heavy rain.

Why use a grassed waterway?

Pacific Island farmers can benefit from building a grassed waterway on their farm. Using this practice can:

- reduce soil erosion.
- prevent rills or channels forming in the soil.
- serve as an outlet for hillside ditches, diversions and terraces.
- carry water down slopes without causing damage.
- reduce and control flooding.
- keep water clean.
- provide water, food and shelter for wildlife.

To learn more about protecting your farm land from water damage, read ***Protecting Soil on Pacific Island Farms***.

Where are grassed waterways used?

- Where water collects and flows on your farm.
- Where water outlets from hillside ditches, roof runoff structures, terraces, diversions, or other man-made features.

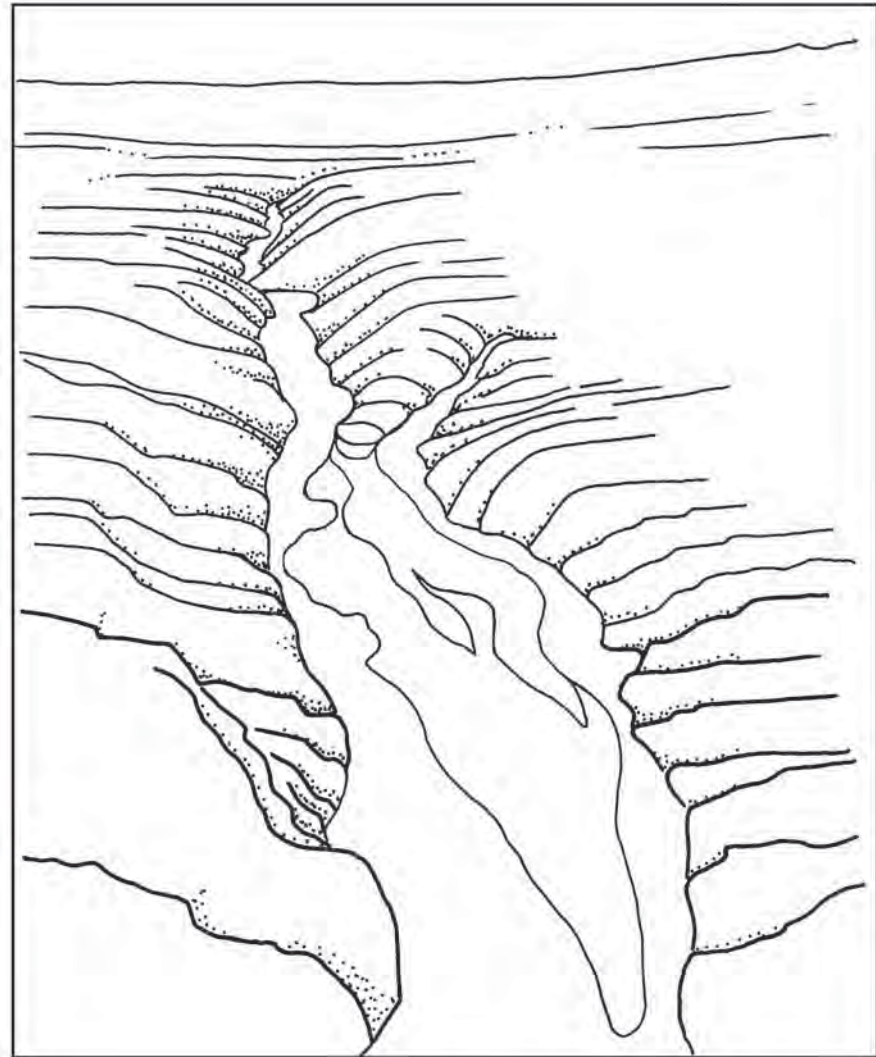
Plan for your grassed waterway

You can use grassed waterways to safely move water across your land. To know how to design a long-lasting waterway, you must watch two things during a rainstorm:

(1) How much water is flowing in the fields? Large volumes of water draining from many acres of land need a large waterway. Small volumes of water can be carried in a smaller channel.

(2) How fast is the water moving? Fast moving water has a lot of power to cut into the soil and will need a strong channel lining.

Go out during a strong rainstorm and watch how water moves across your land. Waterways will usually be needed in the areas where water flows in a small channel.



Go out during a strong rainstorm and watch how water moves across your land. Waterways will usually be needed in the areas where water flows in a small channel.



A grass with a strong root system can be a good lining for a waterway. Sometimes a stone center is needed.

You may have to reshape these areas into wide, flat channels and then strengthen the channel lining with strong fibrous grasses or even heavy angular rock.

Waterway Shape: The shape of a waterway or ditch makes a big difference. Wide flat ditches can spread water out and slow down its speed. Narrow V-shaped ditches take less space in the field, but tend to concentrate water into a small area and cut down into the ground. You can adjust the shape of the waterway to spread out and slow down water.

Grasses: Rough, irregular surfaces and long grass slow water down. A grass with a strong root system can be a good lining for a waterway. Sometimes if water is flowing too quickly, it can tear out grass. A stone center in the waterway may help, using rough angular rock.

For good plant growth in your new grassed waterway:

- choose grasses with strong, deep roots that grow closely together.

- plan for the grass to take about 3 to 6 months to grow strong enough to carry water without having an erosion problem.
- mow as needed to maintain the desired grass length.

All waterways should be designed by a trained professional. For technical assistance to design and build your grassed waterway, as well as for current lists of suggested plants suitable for grassed waterways on your farm, contact your local office of the USDA NRCS.

For the best results, combine **grassed waterways** with other conservation practices:

- **Vegetative Barriers** (601): growing small strips of stiff plants across the slope
- **Hillside Ditch** (423): digging a small ditch across the slope to divert rainwater
- **Roof Runoff Structures** (558): gutters, downspouts and outlets to collect rain
- **Terrace** (600): an earth embankment, or a combination ridge and channel, constructed across the field slope
- **Diversion** (362): a channel constructed across the slope to move water in a desired direction

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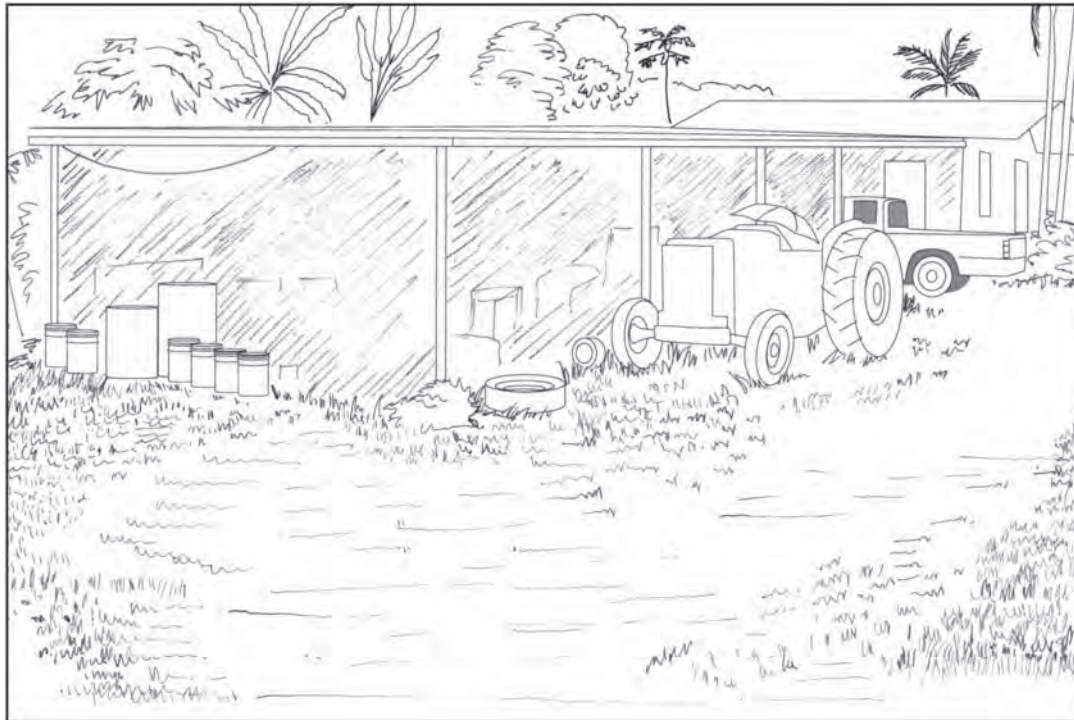


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Heavy Use Area Protection

USDA NRCS Practice (561)



In areas with foot, animal and vehicle traffic, stabilize bare soil to get rid of mud puddles, dust, and wash outs. This will save money and make life on the farm more pleasant.

What is heavy use area protection?

Some areas on the farm get a lot of frequent and intense use by people, animals and vehicle traffic, which leaves bare patches of dirt for long periods of time. When it is very dry, these areas produce dust. When it rains, these areas form big puddles or wash downhill. Pacific Island farmers can reduce dust, puddles, and wash-outs by strengthening or reinforcing these heavy use areas.

To be stable under intense long-term use, heavy use areas may need a thick layer of mulch, ground coral or gravel, or even a coating of asphalt, cement or concrete.

Why protect heavy use areas?

Pacific Island farmers can benefit from stabilizing heavy traffic areas on the farm. Using this practice can:

- improve drainage and dry out standing water.
 - prevent erosion problems.
 - reduce long-term labor and maintenance costs.
-

- improve farm appearance and quality of life.

Where is heavy use area protection used?

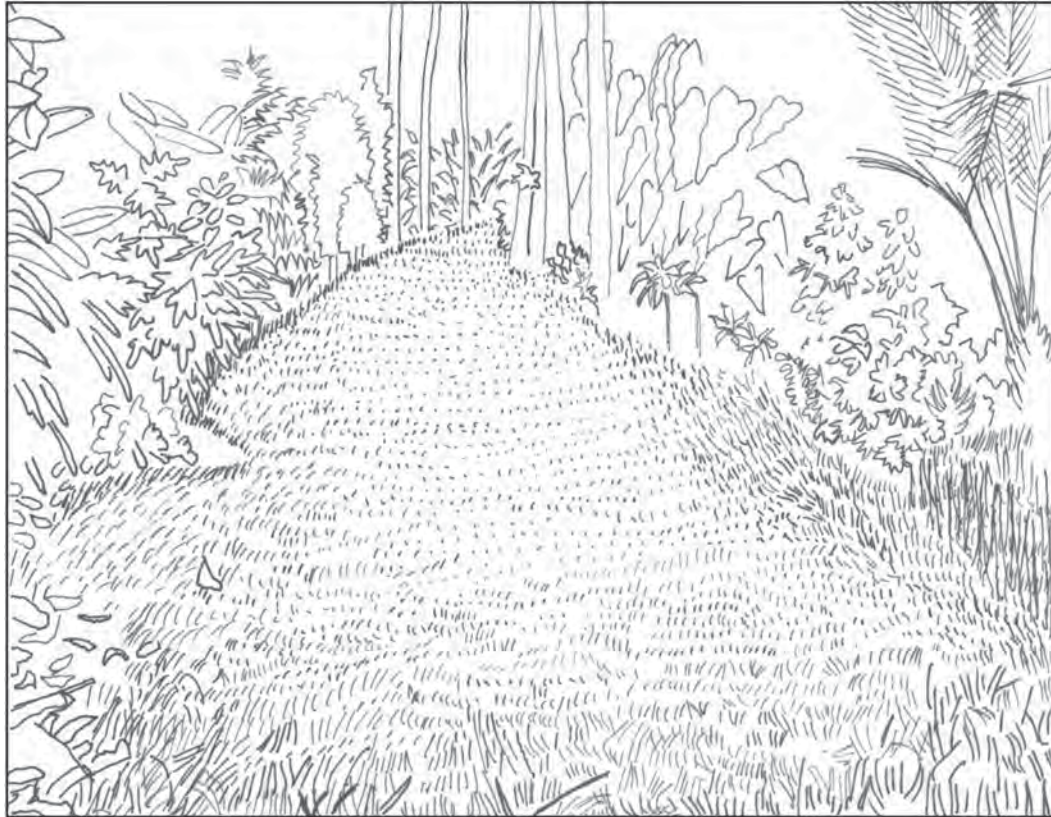
- In bare areas around farm buildings where there is a lot of foot, animal, or vehicle traffic (such as corrals, livestock holding areas, vehicle and equipment parking areas, loading and unloading areas, and post-harvest processing areas)
- As a working surface at plant nurseries
- In pastures with grazing animals, near water and mineral sources, under shade trees and along animal trails and walkways.

Examples of Heavy Use Area Protection Measures

Vegetation: For light use areas, sometimes a very strong and thick grass can be grown or sod put down. If using grass, choose one that can survive some foot and animal traffic, plus some light machinery and vehicles driving on it.



Often heavy use protection is needed in pastures with grazing animals, near water and mineral sources, under shade trees and along animal trails and walkways.



For light use areas, sometimes a very strong and thick grass can be grown or sod put down. If using grass, choose one that can survive some foot and animal traffic, plus some light machinery and vehicles driving on it.

Mulch: For moderate use areas, sometimes a 3-4 inch (8-10 cm) layer of natural material such as chipper waste, betel nut waste, or wood chips will work well. A 2-inch (5 cm) layer of crushed coral, cinder, brick chips, shredded rubber, or sawdust can be used to cover and protect heavy use areas.

Gravel: Moderate to heavy use areas may need a layer of 3-4 inches (8-10 cm) of cinders, gravel, or crushed coral to provide good protection. These materials last between 1-2 years.

Pavement, Concrete, Asphalt/Tar and other Cementing Materials: Areas with very heavy use may need a hard layer to protect them. Materials like bituminous pavement and concrete are generally expensive to buy and install.

Foundation: Sometimes heavy use areas need a very strong foundation to last a long time while carrying heavy loads from vehicle and truck traffic. It may be necessary to dig out the existing soil and replace it with a

layer of gravel (or crushed stone) and a geotextile (a special barrier cloth). Again, work with a qualified professional to plan and build these farm improvements.

Downslope Filter Strips and Buffers: Clean the dirty water draining downhill from a heavy use area by letting it slowly filter through a wide strip of living plants. Direct dirty runoff water to natural undisturbed areas planted with thick vegetation. If there is no natural area downhill, grow a strip of plants across the slope. Plant the filter strip with thick grasses or grow a buffer with a combination of grasses, shrubs, and trees.

For assistance to plan, design or construct heavy use area protection, contact your local USDA NRCS field office.

For the best results, combine **heavy use area protection** with other conservation practices:

- **Mulching** (484): bringing in material to cover and protect the soil
- **Prescribed Grazing** (528): using grazing animals to control plant growth
- **Fence** (382): a constructed barrier to animals or people
- **Use Exclusion** (472): protecting an area by keeping animals, people, or vehicles out
- **Critical Area Planting** (342): planting permanent vegetation on problem sites
- **Filter Strip** (393): a band of vegetation planted between working lands and environmentally sensitive areas

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Hillside Ditches for Steep Slopes

USDA NRCS Practice (423)



On sloping fields, use hillside ditches to keep valuable topsoil in its place, to slow water down, and to let it soak into the soil.

What is a hillside ditch?

Hillside ditches are shallow ditches built along the contour of hillside slopes where fields are planted. Pacific Island farmers use **hillside ditches** to protect their land from erosion.

Why build a hillside ditch?

Pacific Island farmers can benefit from using hillside ditches on their farm. Using this practice can:

- prevent the flow of water from accumulating as it moves downhill, eroding the land.
- help redirect small amounts of rain water into stable areas.
- break long slopes into shorter segments to intercept surface runoff.

To learn more about protecting your farm land from water damage, read ***Protecting Soil on Pacific Island Farms***.

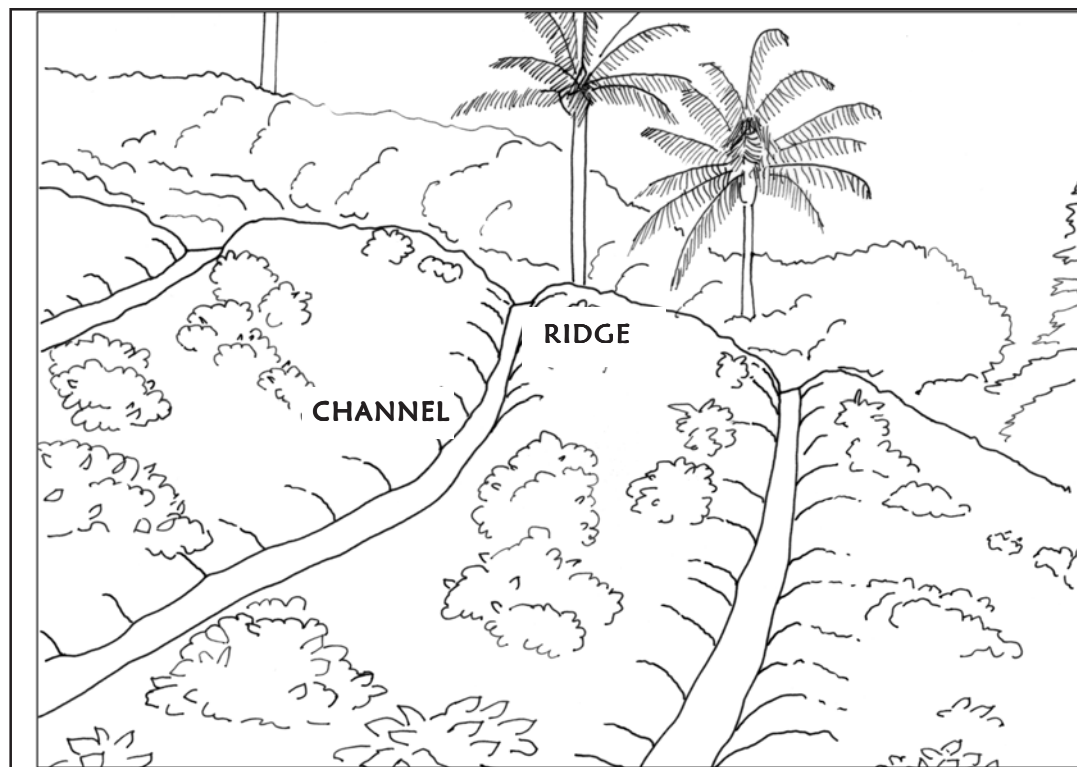
Where are hillside ditches used?

- In crop fields and orchards on steep slopes

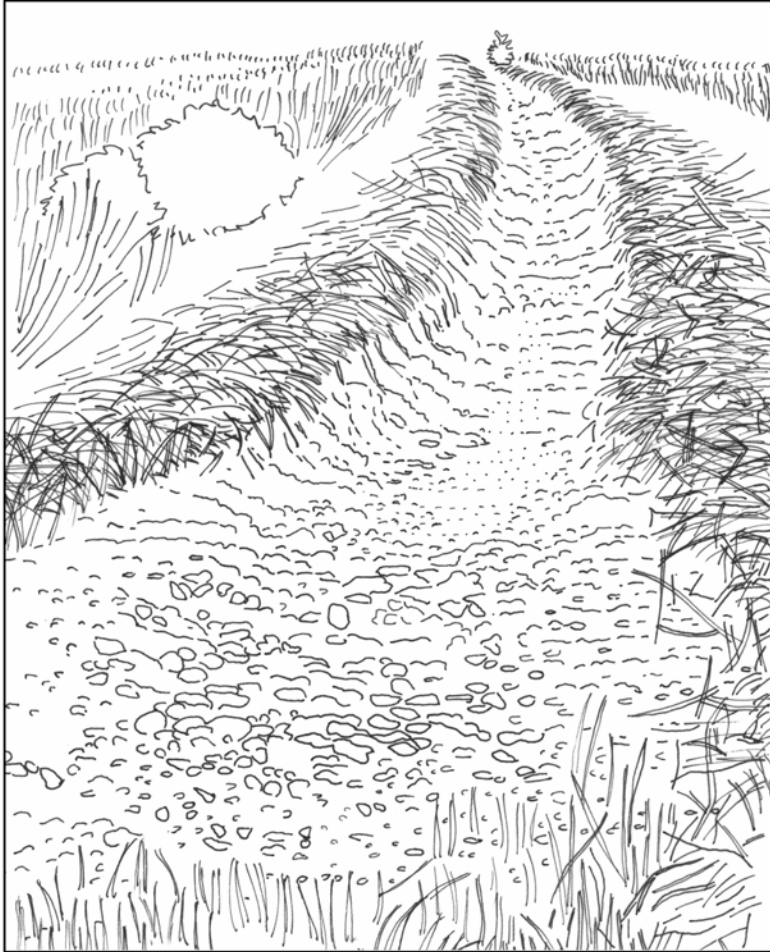
Plan for your hillside ditch system

Often it is difficult to get water to change direction on a slope. Build hillside ditches with both a dug out channel and a small supporting berm (ridge) on the lower side of the slope. This helps rain water stay in the ditch and not flow down hill causing damage in the field.

Spacing: Dig hillside ditches closer together on steeper slopes, about 25 feet apart (7.26 meters). As slopes become gentler, farmers can build them farther apart (35 or 40 feet / 11 to 12 meters). Hillside ditches shouldn't be more than 400 feet long (122 meters) and should be across the slope (no steeper than 2% slope in the channel at the very most).



Dig hillside ditches closer together on steeper slopes.



Be sure that the end of the ditch flows to a stable area with a cover of well-rooted plants or with gravel and rocks.

Ditch outlet: Be sure that the end of the ditch flows to a stable area with a cover of well-rooted plants or with gravel and rocks. Otherwise you can cause erosion in another area on the farm by outletting water in a weak area. You may need a grassed waterway at the ditch outlet.

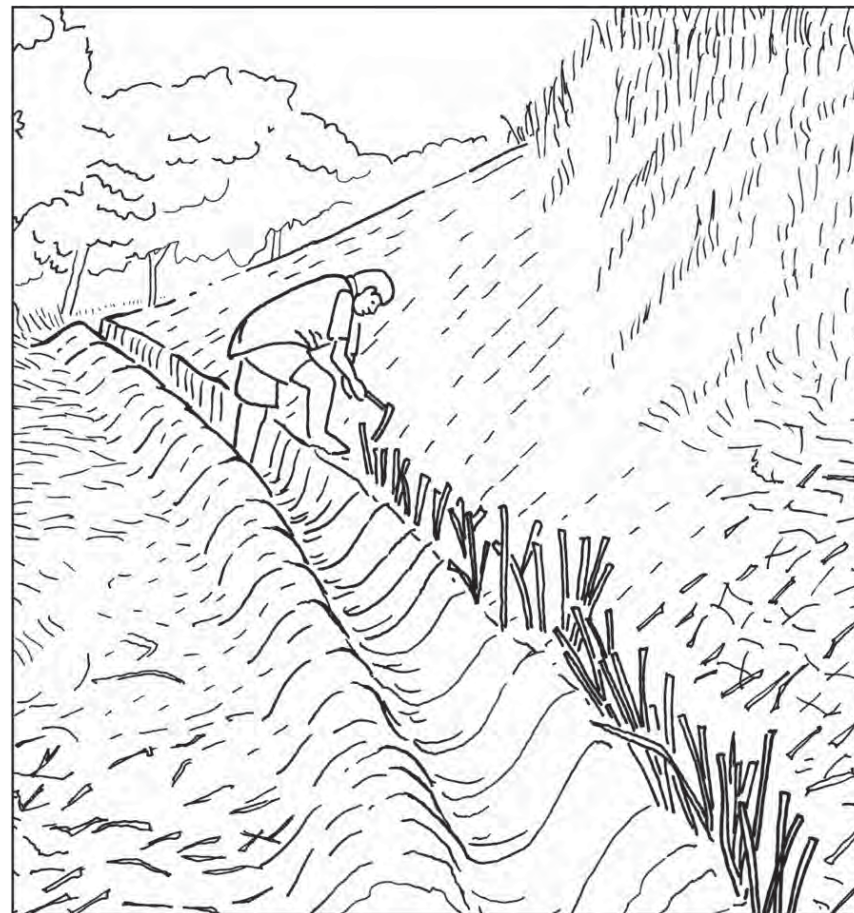
Check with USDA NRCS technical staff for recommendations on how deep and how wide to build the ditch.

For the best results, combine **hillside ditches** with other conservation practices:

- **Vegetative Barriers (601):** growing small strips of stiff plants across the slope
- **Contour Farming for Cropland (330):** carrying out farm operations across the slope

- **Contour Farming for Orchards (331):** carrying out farm operations across the slope
- **Residue Management (329):** leaving slash in the field for soil protection
- **Grassed Waterway (412):** a vegetated channel to carry water without erosion problems

For assistance to plan, design or construct a hillside ditch, contact your local USDA NRCS office. Additional information is available from your local USDA Service Center or at www.pb.nrcs.usda.gov and www.hi.nrcs.usda.gov.



For the best results, combine hillside ditches with vegetative barriers and other conservation practices.



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Mulching

for Moisture, Weed Control and Soil Protection

USDA NRCS Practice (484)



Use mulch around your crops to help smother weeds, conserve water, protect the soil, and provide nutrients.

What is mulch?

Mulches are usually plant materials like chopped leaves, small branches, coconut husks, grass clippings and wood chips placed in a thick layer on the soil surface. Other mulching materials common on Pacific Island farms include coconut fronds and husks, old coconut mats, banana leaves, breadfruit leaves, betel nut wastes, forest tree leaves, cardboard and chipped typhoon debris.

Why use mulch?

Pacific Island farmers can benefit from using mulch on their farm. Using this practice can:

- protect the soil surface and help stop raindrop erosion.
- feed crops and increase the crop yield.
- add organic matter to the soil.
- protect soil around new plantings.
- smother weeds.
- hold moisture in the soil.

To learn more about protecting your farmland from water damage, read ***Protecting Soil on Pacific Island Farms.***

Where and when is mulching used?

- Between rows in crops
- Under fruit and other trees
- In areas with heavy foot or machine traffic
- In heavily shaded areas where vegetation will not grow well
- On soils that don't allow water to soak into the ground
- Throughout the growing season, and especially when crops are still small and getting started
- Between growing seasons when fields are left unplanted

Compost, a special kind of mulch

Composted waste (like grass, shrub and tree trimmings, leaves, and fruits) release plant nutrients as they decompose. Animal manures can be mixed with them to provide more nutrients. To compost, make a light, fluffy mixture of plant and animal waste and arrange it in piles, rows, or bins. Turn the pile from time to time and allow the mixture to cure for a few weeks. The finished, earthy material can be used on your crops. Your local Cooperative Extension Service can provide more information on composting.



Use mulch between rows in crops, in areas with heavy foot or vehicle traffic, when crops are still small, and between growing seasons when field are left unplanted.

Common Mulch Materials for Pacific Island Farms

Material	Layer/Depth	Life Span of Material	Notes
Chipper wastes	3 to 4 inches	6 months	Chipped debris (bark/leaves)
Compost	3 to 4 inches	6 to 8 months	Best used as soil conditioner
Lawn clippings, cut grasses or weeds	1 to 2 inches	1 to 3 months	Don't bring weed seed or weeds into your field
Newspaper	3 to 6 sheets	2 to 6 months	Avoid glossy paper, color prints
Woven weed barrier	1 layer	3 to 5 years	Check product label
Plastic film	1 layer	10 to 36 months	Check product label for lifespan
Wood chips	3 to 4 inches	6 to 9 months	Wood chips can take nitrogen from the crops

For current lists of suggested mulching materials suitable for your farm, contact the local office of the Cooperative Extension Service or the local USDA NRCS field office.

For the best results, combine **mulching** with other conservation practices:

- **Residue Management** (329): leaving slash in the field for soil protection
- **Heavy Use Area Protection** (561): reinforcing high traffic areas on the farm
- **Composting Facility** (317): a facility to produce compost from organic byproducts

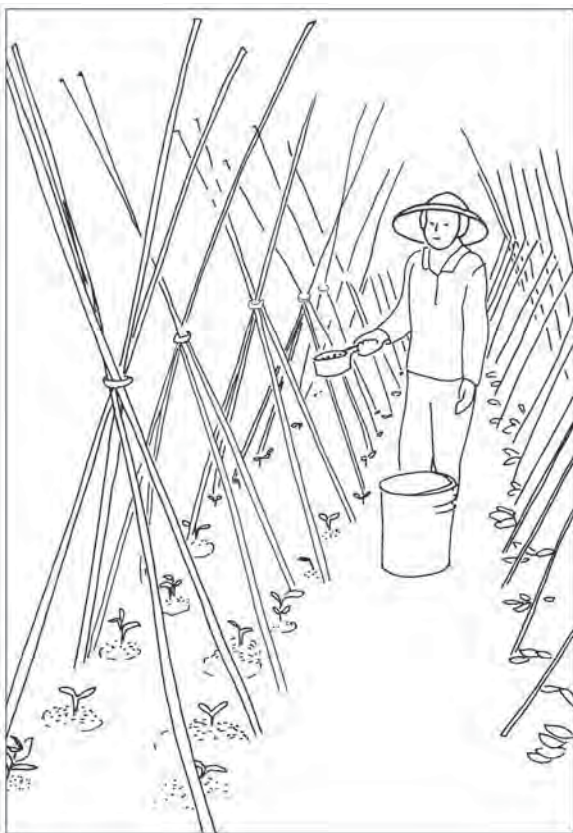
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Mulch works well for soil cover in heavily shaded areas under trees. To prevent trunk rot, don't pile mulch directly against the base of the trees.

Nutrient Management for Pacific Island Farms

USDA NRCS Practice (590)



Use cover crops, compost, animal manures, fertilizers, and other soil amendments to nourish your plants.

What is nutrient management?

When farmers base their fertilizer, cover crop, compost, and manure applications on crop needs, they are using **nutrient management**. Nutrient management is a way to feed crops without wasting money and without contaminating water supplies.

Why use nutrient management?

Pacific Island farmers can benefit from applying nutrient management on their farm. Using this practice can:

- economically provide plant nutrients.
- re-cycle animal wastes for plant nutrients.
- improve the soil with organic matter (from cover crops, compost, and manures).
- protect water sources (wells) and water bodies (streams, rivers, ocean) from nutrient pollution.

Where is nutrient management used?

- On all farmlands where plant nutrients are applied.

Plan for nutrient management

To grow a healthy, high yielding and high quality crop, use cover crops, compost, animal manures, fertilizers, and other soil amendments to nourish your plants. Your local Cooperative Extension Service (CES) is a good source of information for local farmers about crop production questions. They will work with you to be sure you understand what nutrients your crops need, how much natural fertility there is in your soil, and different ways to get nutrients to your crops.

Deciding the Right Amount

Learn what nutrients your crops need to grow well (available from CES). Learn what nutrients are already available in your soil by doing a soil test or plant tissue test, also available from CES. The test results will tell you what to apply and how much. Don't waste your time and money – apply just enough to meet your crop's needs.

Sources of Plant Nutrients

Commercial Fertilizers

After you get your test results, buy a fertilizer that matches your crop needs. The standard fertilizer mixes with fixed amounts of nitrogen, phosphorous, and potassium, like 15-15-15 (often called “triple fifteen”) or 10-30-10, may not be what your crop requires. These fertilizer mixes can result in over-fertilizing your plants. Too much or the wrong kind of fertilizer can cause an imbalance in the soil, making your crops more prone to disease, plus wasting your money. Ask for single-nutrient fertilizers like urea, super phosphate, or potash, and blend your own mixture that will meet your crop's needs.

Organic Nutrient Sources

Commercial fertilizers are not the only source of nutrients for your crops. Other nutrient sources commonly available are cover crops (green manure), compost, animal manure and aquaculture wastewater.



Learn what nutrients are already available in your soil by doing a soil test.





Learn when your crops need nutrients during the growing season. If nutrients are applied when the crops aren't ready to use them, they will be wasted.

Organic materials contain different amounts of nitrogen, potassium, and phosphorous just like chemical fertilizer mixes. Find out the nutrient levels of your organic fertilizers. CES and NRCS can help you find standards (also called “book values”) for common manures and other organic nutrient sources. The best way to know what you are using is to have the material tested for nutrient content. Often CES can provide this service.

When should you apply nutrients?

Consult with CES to determine when your crops need nutrients during the growing season. If nutrients are applied when the crops aren't ready to use them, they will be wasted or leached into the underground drinking water supply. You may need to use several smaller fertilizer applications (known as split applications) during the growing season or use a slow-release fertilizer to apply nutrients as plants need them.

Don't waste valuable time and money by applying soluble fertilizers or manures right before heavy rains. They will wash away and may pollute water supplies.

Nutrient Placement

- Calibrate your equipment to be sure you are applying the correct amount of fertilizer.
- Instead of broadcasting nutrients, you may need to put fertilizer in a band next to the plants to get the best nutrient uptake.

- Don't use fertilizers near wells and public water supplies, drainage ditches, ponds, streams, rivers, or wetland areas.

Record Keeping

A large part of good nutrient management is record keeping. Write down what you apply, when, and how much. Make note of other field observations, like crop yield and pest problems. Keep a file with your notes, fertilizer bag labels, and other information. All of this will help you tailor your nutrient management plan for what is right for your crops, your soil, and the environment.



For the best results, combine **nutrient management** with other conservation practices:

- **Cover Crops** (340): growing legumes, grasses or grains for nutrients and weed control
- **Filter Strips** (393): A band of vegetation planted between working lands and environmentally sensitive areas

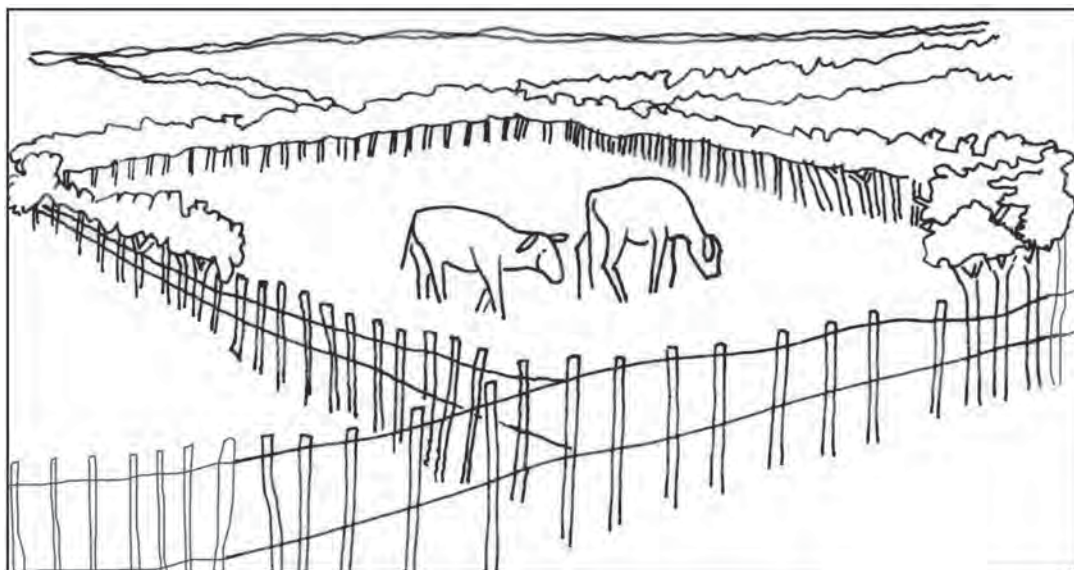
On sloping fields:

- **Contour Farming for Cropland** (330): carrying out farm operations across the slope
- **Contour Farming for Orchards** (331): carrying out farm operations across the slope
- **Hillside Ditch** (423): digging a small ditch across the slope to divert rainwater
- **Vegetative Barriers** (601): growing small strips of stiff plants across the slope
- **Alley Cropping** (311): growing strips of trees across the slope between areas where crops are planted

Additional information on nutrient management and other conservation practices is available from your local USDA Service Center or at www.pb.nrcs.usda.gov and www.hi.nrcs.usda.gov.

Prescribed Grazing for Pacific Island Farms

USDA NRCS Practice (528)



Use prescribed grazing to lower feed costs, control weeds, simplify manure management, and reduce pests and diseases that can harm your farm animals.

What is prescribed grazing?

Prescribed grazing (or rotational grazing) is a way for Pacific Island farmers to make the best use of their available pasture land to feed their grazing animals (cattle, sheep, goats, carabao). It is done by dividing the farm into paddocks with fencing, and then moving the animals through them for a short period of time.

Why do prescribed grazing?

Pacific Island farmers can benefit from using prescribed grazing on their farm. Using this practice can:

- lower purchased feed costs.
- improve the health of your animals.
- lower weed control costs.
- simplify manure management.
- prevent soil erosion and keep manure and urine out of waterways.
- reduce animal pests and diseases.

Where is prescribed grazing used?

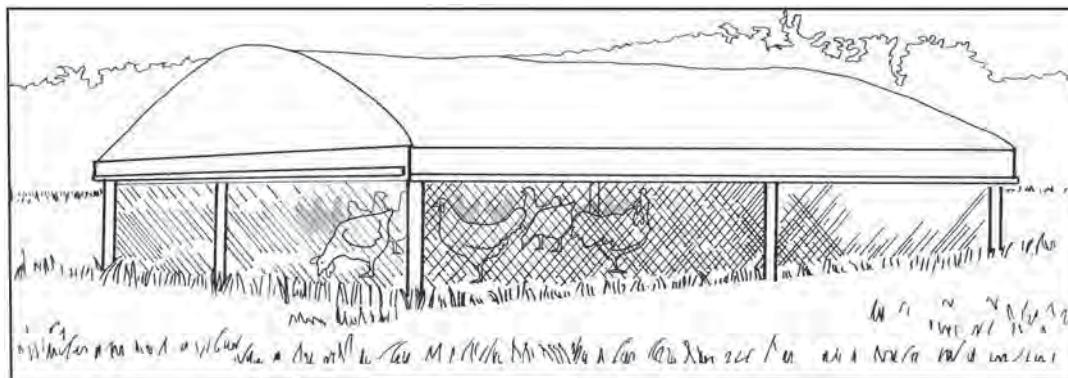
- On many farms with many types of livestock
-

Plan for prescribed grazing

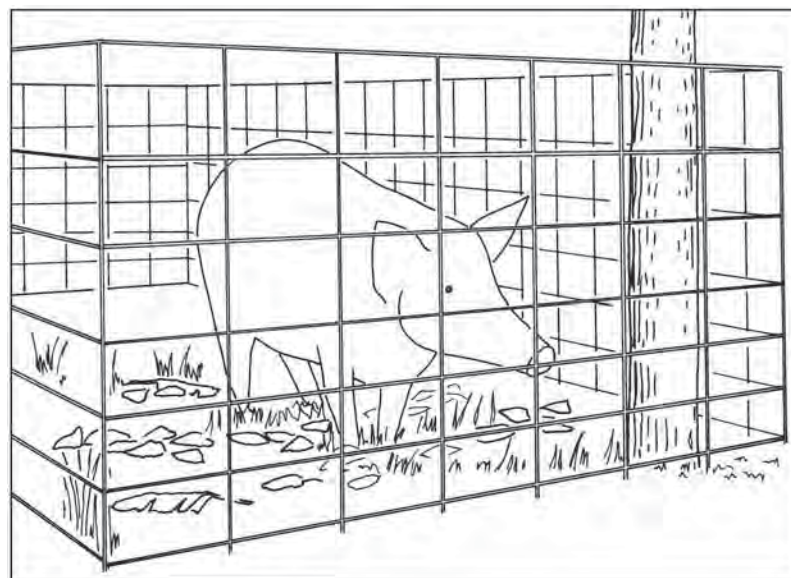
You may be able to increase the number of animals you raise, feed your animals better and at a lower cost, and keep them healthier by using a prescribed grazing system. Moving animals across the farm avoids build up of manure and urine, and makes manure management easier. By keeping animals away from streams and wells, you can prevent water contamination. Prescribed grazing takes some planning, some experience, and some initial investments in fencing.

Fencing

Temporary, portable electric fencing is useful for prescribed grazing systems. Divide the farm into paddocks with fencing, and then move livestock through them to graze for a short period of time (1-14 days). Use fencing to control animal traffic. Areas near water and mineral sources, under shade trees, and along trails and walkways tend to get damaged by animal traffic. By changing fencing location and moving water and mineral sources, animal traffic patterns can be managed.



Example of a portable pen system for chickens



Example of a portable pen system for pigs



A flexible watering system can help you move your animals around the pasture and avoid damage to the area around their water source.

How to select the pasture areas on your farm

- Be sure the plants you are growing are a good match for your animal's nutritional needs. Check for toxic weeds.
- Graze an area until about half of the plant material has been eaten. Then allow the plants 18 to 25 days to re-grow.
- To reduce feed costs and improve the health of your animals, you may want to improve the quality of the forage by growing more nutritious plants such as improved forage grasses and legumes. You can often improve pasture areas with fertilizer and lime, weed control, reseeding and other types of pasture management.

Managing your animals

- Use permanent or portable fencing to keep your animals where you want them. Fencing can help with predator control too.
- Don't put too many animals on the land. They can permanently damage your fields. During drought times, when there is less forage growth, decrease the number

of grazing animals to avoid damaging your ground cover plants. Keep more than 80% of the ground covered by plants at all times.

- Provide water for your animals. Use a permanent water system or portable watering device. The zone around the water source tends to build up manure and urine and becomes a source of parasites and disease. A flexible watering system can help you move your animals around the pasture and avoid damage to the area around their water source.
- Provide shelter and shade for your animals. Trees can provide shelter in many areas, or use portable shelters.

The USDA NRCS or your local Cooperative Extension Service can help you design an annual grazing plan that will include:

- size and location of paddocks.
- number of days of grazing and days of rest.
- number of animals that can be supported on the forage found on your farm.
- farm map with fencing, water supplies, and forage resources.

For the best results, combine **prescribed grazing** with other conservation practices:

- **Fence (382):** a constructed barrier to animals or people
- **Water Sources:** watering facility (614), pond (378), spring development (574), water harvesting catchment (636), water well (642)
- **Animal Trails and Walkways (575):** a constructed way to move livestock through difficult or environmentally sensitive areas
- **Heavy Use Area Protection (561):** strengthening on-farm areas with frequent intense use
- **Manure Control:** manure transfer (634), composting facility (317); waste storage facility (313), waste treatment lagoon (359), waste utilization (633)
- **Pasture Improvement:** pasture and hay planting (512), range planting (550)

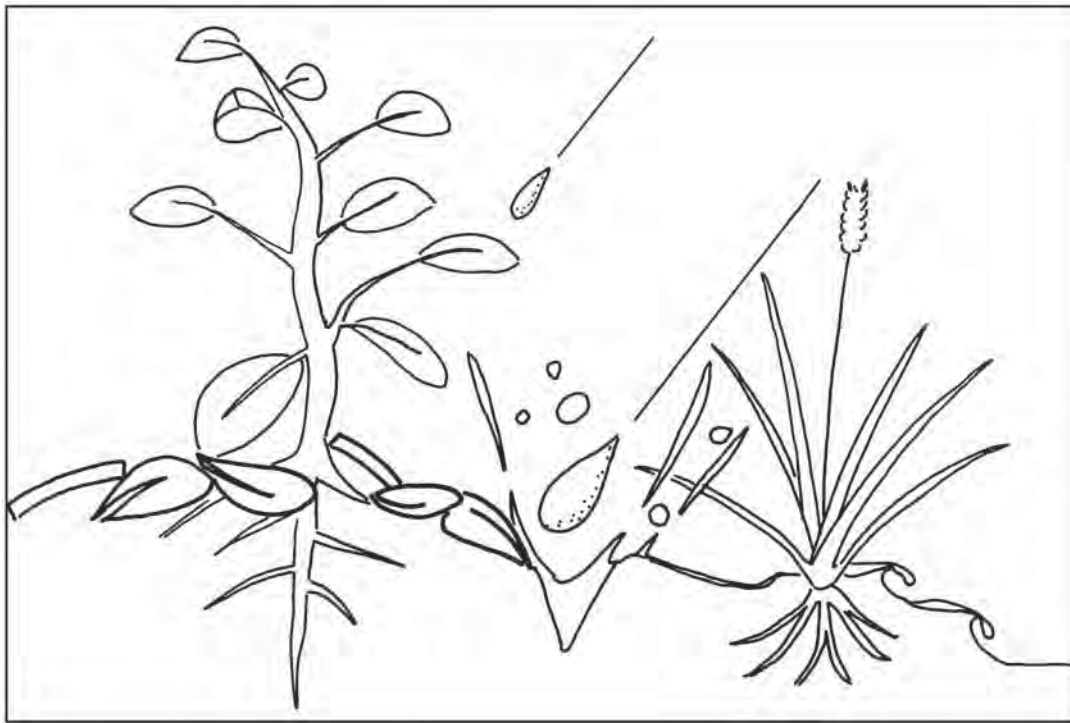
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Protecting Soil on Pacific Island Farms



Raindrop or splash erosion washes away valuable topsoil, making fields less fertile. Use simple conservation practices like mulching, residue management, cover crops and conservation covers to protect the soil from raindrop erosion.

What is soil erosion?

Soil erosion is the breaking apart, dissolving, wearing down, and moving of rock and soil. It is caused by water, wind, animals and humans, and gravity. Some erosion is natural, but poor farming practices, over-grazing and improper tree harvesting can greatly speed it up and cause damage to the land.

Erosion can be a problem on your farm because:

- It washes away valuable topsoil, making your fields less fertile.
- It may wash away large sections of stream bank.
- Soil can clog up streams and rivers causing flooding problems on-farm and downstream.
- Soil settling on coral can kill reefs, damaging island fishing areas.
- It may wash away pesticides and nutrients, causing water pollution that is harmful to fish and other water creatures.

What does erosion look like?

1. Raindrop or “splash” erosion: Falling raindrops hit bare soil with a lot of power, moving soil particles up to 5 feet (2 meters) away. Larger drops from tropical rainstorms and typhoons have even more power. Once soil is detached, flowing water can move it easily.

2. Sheet and rill erosion: As rain collects, a thin film or sheet of water moves across the surface of the ground, removing a thin layer of soil in bare areas. Moving water collects into small little channels (called rills) or larger channels (called gullies), cutting even more deeply into the soil surface. Rills usually cut down only a few inches.

3. Gully erosion: Gullies can be many feet deep and cause much damage to a farm field. Once water concentrates into channels, it has the power to move very large amounts of valuable soil. A field badly eroded by water will have thinner, less fertile soil and gullies that equipment cannot cross.

4. Stream and channel erosion: Streams and rivers carry larger amounts of water at higher speeds. Huge sections of stream or riverbank can be torn away during big storms.

How should Pacific Island farmers control erosion?

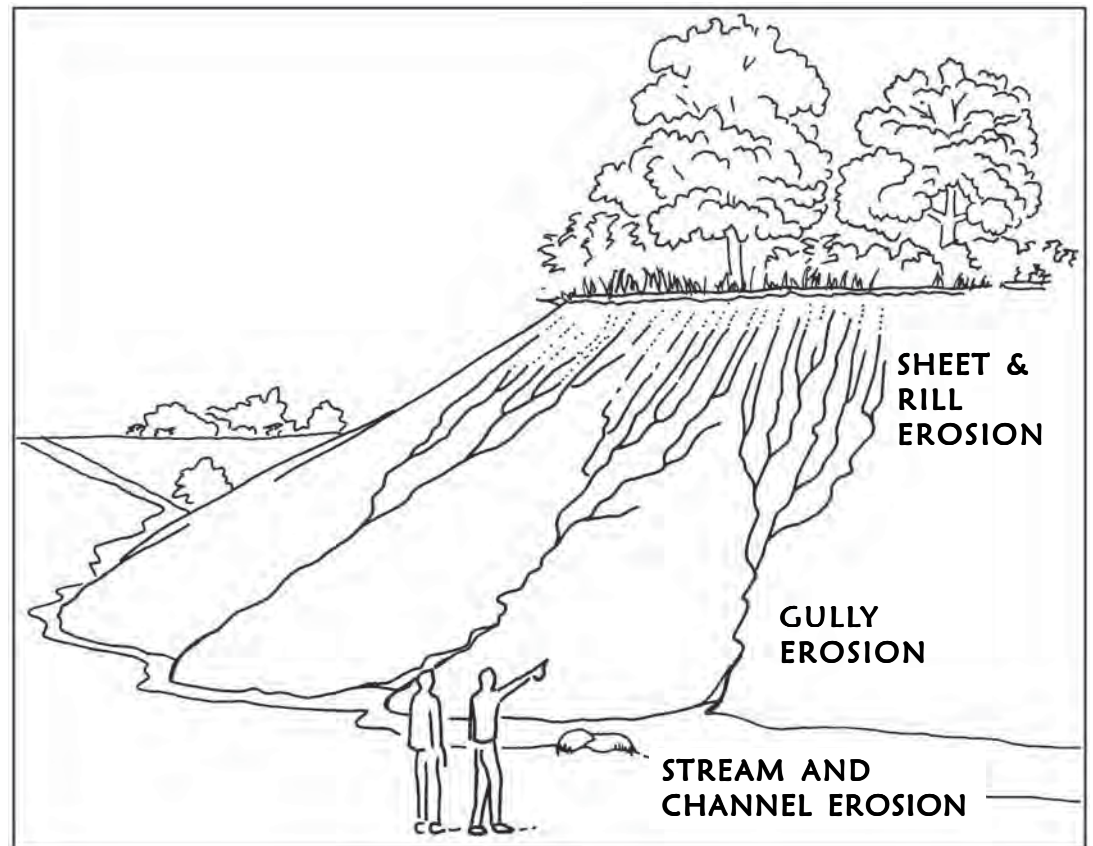
You cannot control some things in nature, like climate or soil type. But you can control other things like plant cover and slope length by using the conservation practices explained below.

Soil

You can manage your topsoil to slow down erosion. By adding organic matter to your soil (as a mulch, compost, or cover crops) you can enrich and loosen up the soil, getting more water to filter down into the ground.

Consider using the following practices to help improve soil health and increase water held in the soil for crops.

- ☐ Cover Crops (340) or Conservation Covers (327)
- ☐ Tree/Shrub Establishment (612)
- ☐ Mulching (484)
- ☐ Residue Management (329)



Use mulch around your crops to help smother weeds, conserve water, protect the soil, and provide nutrients.



Plant Cover

To prevent **raindrop erosion**, protect the soil surface year round with a thick cover of living plants or with mulch (chopped leaves, small branches, coconut husks, wood chips, etc.). Plant cover protects the soil surface from the impact of falling rain and slows the speed of rain runoff. Plant roots help loosen the soil and let water soak into the ground. Plant root systems hold soil particles in place.

Consider using the following practices to keep bare soil covered year-round:

- ☐ Cover Crops (340) or Conservation Covers (327)
- ☐ Tree/Shrub Establishment (612)
- ☐ Mulching (484)
- ☐ Residue Management (329)

Slopes

Slope length, steepness and surface roughness affect erosion. Water flows fast down slopes that are long, smooth, and straight. Water traveling at high speed has power to cut down into the soil, making **rills** and **gullies**.

Consider using these conservation practices to shorten slope lengths, make them more irregular, and slow down rainwater:

- ☐ Hillside Ditch (423)
- ☐ Contour Farming for Cropland (330)
- ☐ Contour Farming for Orchards (331)
- ☐ Alley Cropping (311) and Hedgerow Planting (422)
- ☐ Residue Management (329)
- ☐ Vegetative Barrier (601)



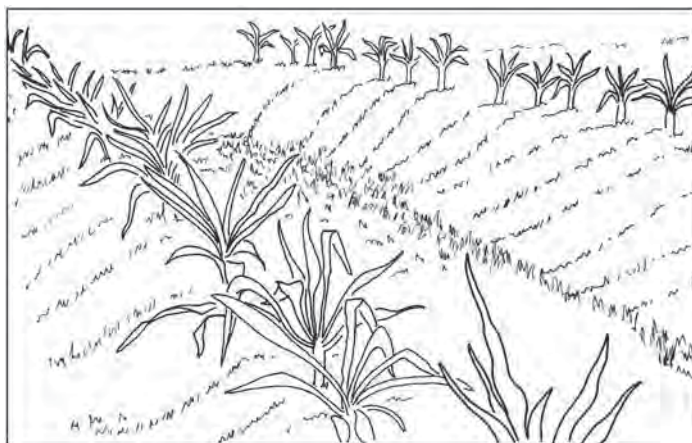
On sloping fields, use hillside ditches to keep valuable topsoil in place and to slow water down and let it soak into the soil.

Flowing Water

In areas on the land where water runs seasonally or year round (drainage ditches, seasonal and year-round streams), you may need to strengthen the waterway lining to be sure **stream** and **channel erosion** is prevented. USDA NRCS professionals can calculate water volume and velocity and recommend long-lasting channel linings for waterways on your farm. Grassed waterways can usually handle smaller amounts of slow moving water. Stone or concrete linings are often needed for larger volumes or higher velocities of water.

Consider using these conservation practices for areas with flowing water:

- ☐ Grassed Waterway (412)
- ☐ Vegetative Barrier (601)
- ☐ Channel Bank Vegetation (322)



Build grassed waterways to carry water across fields and down steep slopes. They also serve as an outlet for roof runoff structures and hillside ditches.

Animal Management

Grazing animals can cause erosion with their hooves when drinking water from streams. Prevent erosion by fencing them out or by strengthening the watering areas. Animals can also eat all the plant cover, leaving the soil bare.

Consider using these conservation practices to help protect stream banks from livestock damage:

- ☐ Fencing (382)
- ☐ Heavy Use Area Protection (561)
- ☐ Prescribed Grazing (528)
- ☐ Watering Facility (614)
- ☐ Animal Trails and Walkways (575)

Heavy Use Areas

Some areas on the farm get so much heavy traffic and use that they need additional work to help prevent erosion. Part of the solution is to move (or divert) clean water away from these heavily used areas. The second part of the solution is to strengthen these areas (with mulch, gravel, etc.) to protect them from erosion.

Consider using these conservation practices to protect heavy use areas:

- ☐ Roof Runoff Structure (558)
- ☐ Heavy Use Area Protection (561)
- ☐ Access Road (560)

Additional information is available from your local USDA Service Center or at www.pb.nrcs.usda.gov and www.hi.nrcs.usda.gov.



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Residue Management:

Using Plant Residues (Slash) for Moisture, Weed Control, and Soil Protection

USDA NRCS Practice (329)



Pacific Island farmers use left over plant materials (leaves, branches, stalks, etc.) called residue or slash on their fields to nourish and protect their topsoil.

What is residue management?

Pacific Island farmers use left over plant materials (leaves, branches, stalks, etc.) called **residue** or slash on their fields to nourish and protect their topsoil.

Leaving soil bare and uncovered in tropical climates often causes problems. Instead of leaving the soil bare in your fields, arrange plant matter left over from the harvest in strips across the slope or beneath orchard trees. Then plant the next crop into the plant matter, by hand either with a digging stick or tool, or with special machinery. This is a very respected and traditional practice used by farmers around the Pacific.

Why use residue management?

Pacific Island farmers can benefit from residue management on their farm. Using this practice can:

- save labor on collecting and burning slash.
 - protect the soil surface and help prevent raindrop erosion.
 - slow water down and let it to soak into the soil.
-

- fertilize the crops and increase the harvest, especially if using slash from nitrogen fixing crops (called legumes) that are rich in nutrients. Organic matter from plant material helps the soil become more fertile and easier to work.
- protect new plantings and smother out weeds.
- provide food and shelter for wildlife.

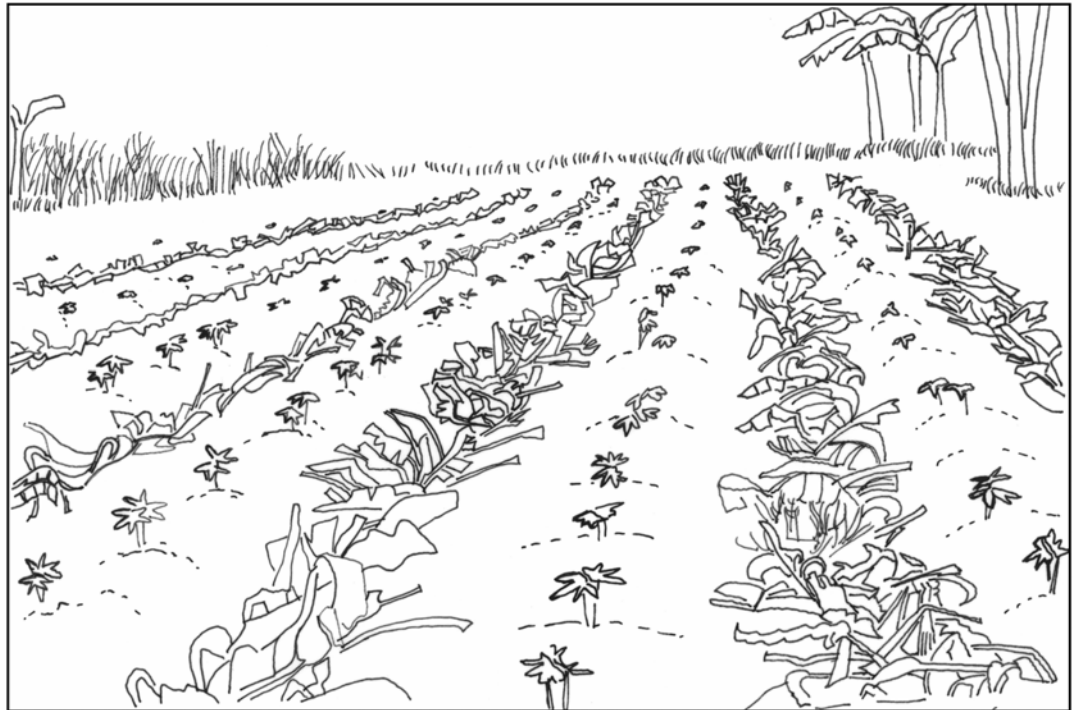
To learn more about protecting your farmland from water damage, read ***Protecting Soil on Pacific Island Farms.***

Where and when is residue management used?

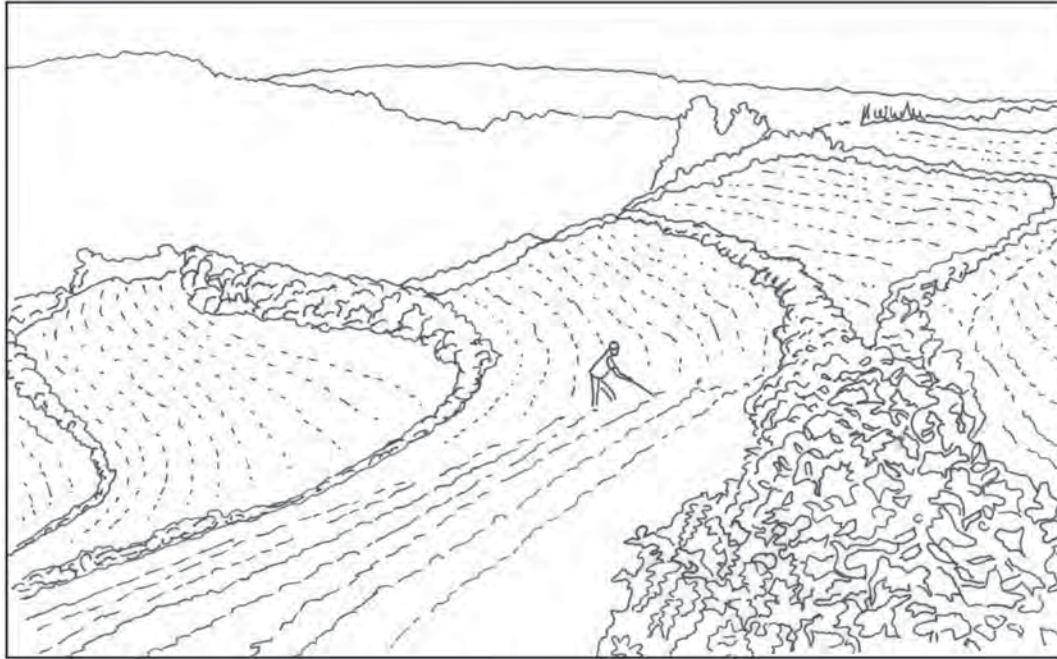
- Between rows in crops
- Under fruit trees
- Early in the growing season when new crops are still small and filling in
- Between growing seasons when fields are left unplanted

Where is residue management not used?

If your field is infected with certain plant diseases, crop residues may infect the next crop. Don't place residue directly against plant



Instead of leaving the soil bare in your fields, arrange plant matter left over from the harvest in strips between rows, across the slope, or beneath orchard trees. Then plant the next crop into the plant matter.



Combine residue management with contour farming and other conservation practices for more soil fertility and slope protection.

stems and trunks. Consider using crop rotations to break disease cycles. Consult with the Cooperative Extension Service about how to manage plant diseases.

Plan for Residue Management

You can use residue management on the farm in several different ways:

(1) **Leave soil covered.** After the harvest, instead of cleaning the fields and burning slash, leave leftover plant material in place. Save time and labor by letting leaves, branches, and stalks break down on the ground until you are ready to plant again. This will protect your valuable top soil from erosion until you are ready to plow.

(2) **Use strip cropping on sloping fields.** Leaving most of your field covered with slash, clear and cultivate small rows (or strips) of ground across the slope for planting. Clear small areas with tilling or through careful applications of herbicide, and plant each section quickly. Between rows, leave strips of soil covered with slash or mulch.

(3) **No Till.** This traditional Pacific Island method to grow food in steep areas is beneficial for the land. Clear the planting area by hand or with spot doses of herbicide. Plant directly into the slash or plant residue left in the field without doing any plowing or tilling. This work is mostly done by hand. There is special equipment (called no-till planters or drills) for this type of cultivation, but it is difficult to locate in the Pacific region.

Weed Management: Sometimes certain weeds can be used to protect the soil while your crop is growing. Weed residue left in the field will provide ground cover between your crop plants. Cut, pull or spot-spray weeds instead of using mechanical tillage, and leave plant material in place.

Do not do this with weeds that grow from cut pieces or that can escape from the farm and become problem weeds in natural areas or forests. Remove these invasive weeds from your land. Consult with your local Cooperative Extension Service about weed management options for your farm.

For the best results, combine **residue management** with other conservation practices:

- **Vegetative Barriers** (601): growing small strips of stiff plants across the slope
- **Hillside Ditch** (423): digging a small ditch across the slope to divert rainwater
- **Contour Farming for Cropland** (330): carrying out farm operations across the slope
- **Contour Farming for Orchards** (331): carrying out farm operations across the slope
- **Alley Cropping** (311) and **Hedgerow Planting** (422): growing hedges of bushes and trees across the slope

Additional information is available from your local USDA Service Center or at www.pb.nrcs.usda.gov and www.hi.nrcs.usda.gov.

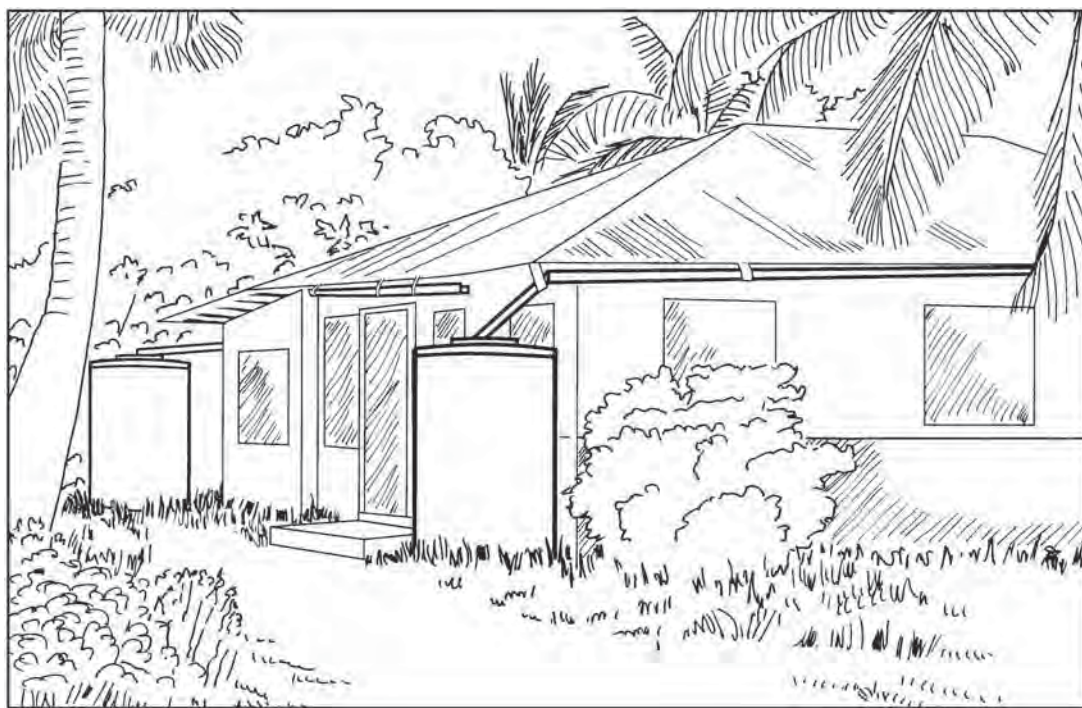


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Roof Runoff Structures to Improve Farm Drainage

USDA NRCS Practice (558)



Many flooding, erosion, and pollution problems can be reduced just by keeping roof rainwater away from buildings and other important areas on the farm.

What are roof runoff structures?

Roof runoff structures are simple gutters, downspouts, and outlets to collect rain from roofs. During heavy rains, very large amounts of water drain off the roofs of farm houses, barns, and other buildings. Many flooding, erosion, and pollution problems can be reduced just by keeping roof rainwater away from buildings and other important areas on the farm.

Why install roof runoff structures?

Pacific Island farmers can benefit from installing roof runoff structures on their farm. Use gutters, downspouts and outlets to:

- keep water from ponding or flooding farm buildings.
 - protect farm buildings from undercutting their foundation.
 - prevent rain water from flowing into animal shelters and pens.
 - prevent rain water from flowing into animal waste areas and washing manure into streams.
 - collect roof rainwater for livestock and irrigation use.
-

Plan for roof runoff structures

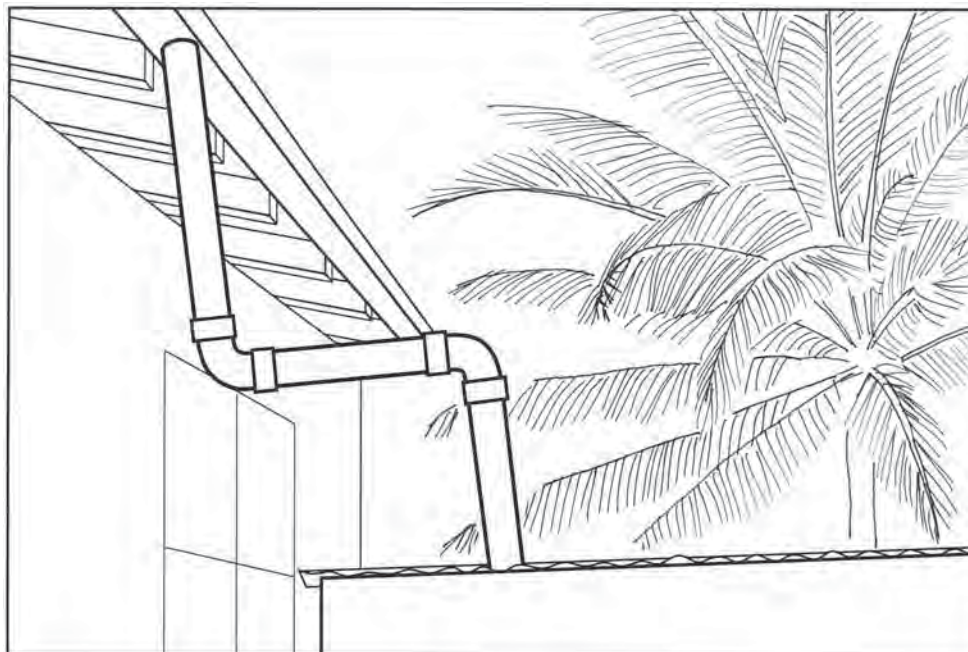
Here is a chart with some suggestions for materials to use for building gutters. For more information, check with your local USDA NRCS Office.

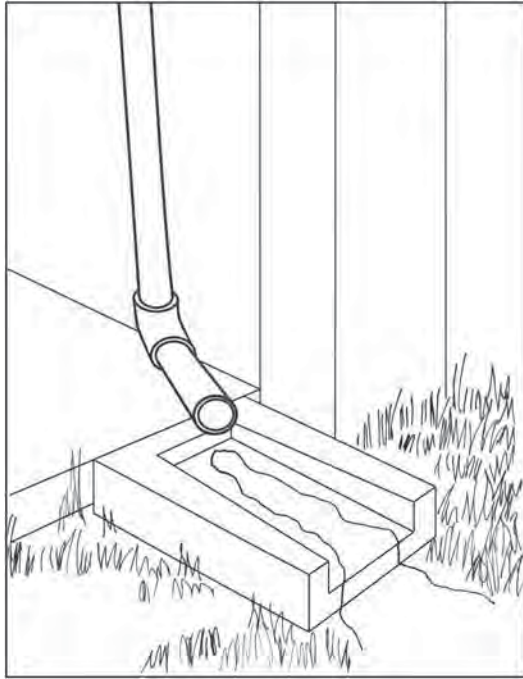
Downspouts: Fasten downspouts securely at the top and bottom with intermediate supports 3 meters (10 ft) apart.

Downspout outlets: Rainwater concentrates in the gutters and then falls down the downspout. By the time it reaches the ground it has a lot of energy. Protect the ground surface located below the downspout from the water's force by having water fall onto splash blocks, into a surface drain, or into a stable rock outlet. To collect water for livestock or irrigation, place a large container or rain barrel under the downspout.

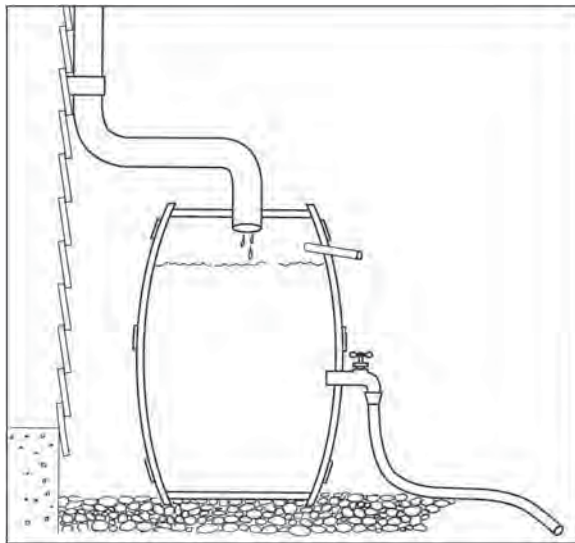
Direct water away from buildings. Move the water away from farm buildings in a pipe, grassed waterway or other stable channel. Clean rainwater should **not** be directed toward certain parts of the farm.

Gutters		
Materials for gutters	Description	Spacing for gutter support
Aluminum	0.5 – 0.7 mm (0.02 – 0.03 in)	81 cm (32 in)
Galvanized steel	28 gauge	120 cm (48 in)
Wood	free of knots paint with water repellant preservative	81 cm (32 in)
Plastic	with UV stabilizers	81 cm (32 in)





Protect the ground surface located below the downspout from the water's force by having water fall onto splash blocks, into a surface drain, or into a stable rock outlet.



To collect water for livestock or irrigation, place a rain barrel under the downspout.

Do not drain rainwater into the following areas:

- where your animals are sheltered or penned.
- where there is a lot of manure or stored manure.
- toward your cesspool.
- toward areas with lots of traffic (from people, animals or machinery).
- toward areas where bare soil is already showing an erosion problem.

Direct collected water to stable areas.

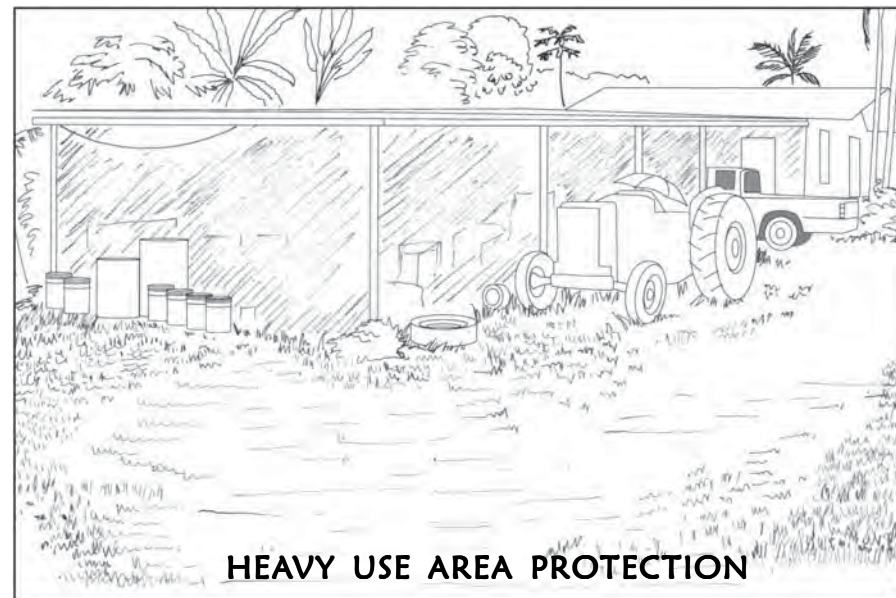
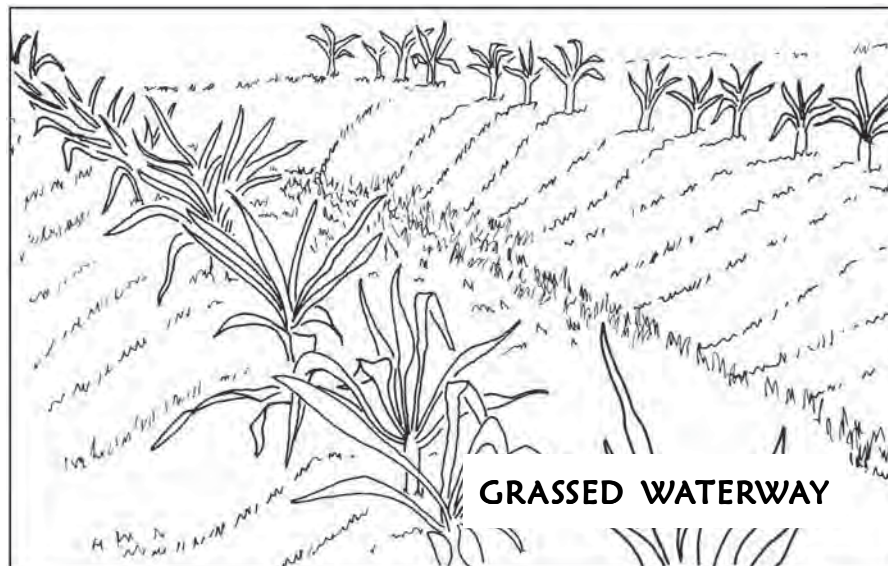
Dump roof runoff water into natural undisturbed areas with thick plant growth. If there is no natural area downhill, grow a strip of plants across the slope. Plant the filter strip with thick grasses or grow a buffer with a combination planting of grasses, shrubs and trees. Some outlet areas may need strengthening with rock or stone.

For assistance to plan, design, or to construct a roof runoff structure, contact your local USDA NRCS field office.

For the best results, combine **roof runoff structures** with other conservation practices:

- **Grassed Waterway** (412): a vegetated channel to carry water without erosion problems
- **Heavy Use Area Protection** (561): reinforcing high traffic areas on the farm

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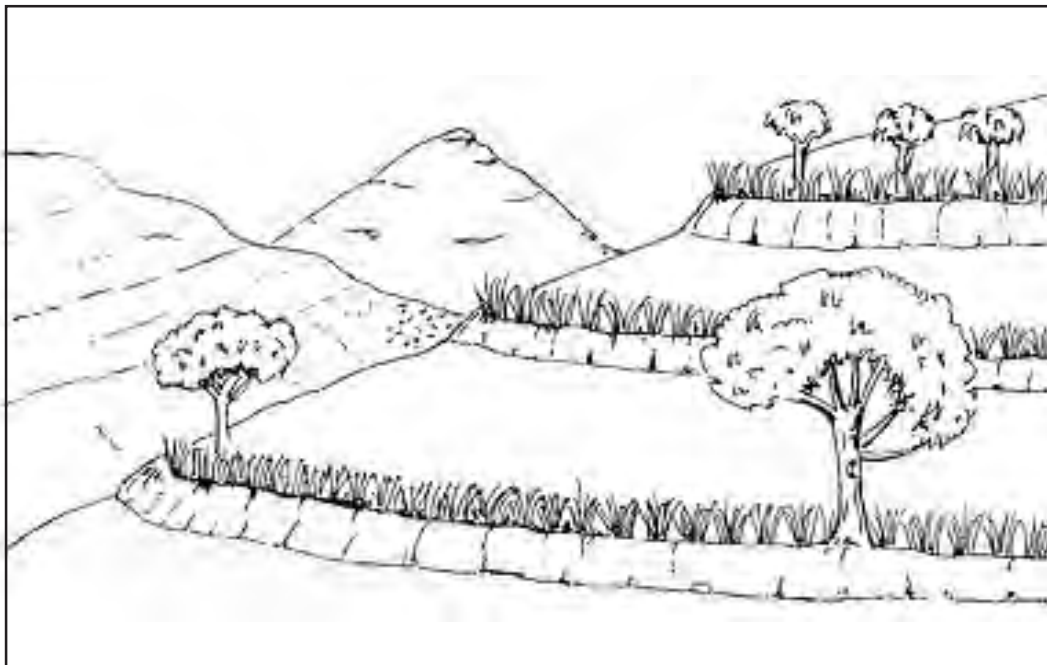
For the best results combine roof runoff structures other conservation practices such as grassed waterways and heavy use area protection.



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Vegetative Barriers for Protecting Topsoil

USDA NRCS Practice (601)



Vegetative barriers are permanent strips of stiff, dense grasses grown across a slope or across a drainage way.

What are vegetative barriers?

Vegetative barriers are permanent strips of stiff, dense grasses grown across a slope or across a drainage way.

Why grow a vegetative barrier?

Pacific Island farmers can benefit from growing a vegetative barrier on their farm. Using this practice can:

- protect topsoil. Barriers help slow rainwater down and filter out soil particles.
- re-direct and divert water across a slope.
- loosen and improve the soil, allowing more water to soak in and be retained.
- stabilize the uphill side of a hillside ditch.
- trap sediment at the bottom of a field.

To learn more about protecting your farm land from water damage, read ***Protecting Soil on Pacific Island Farms***.

Where are vegetative barriers used?

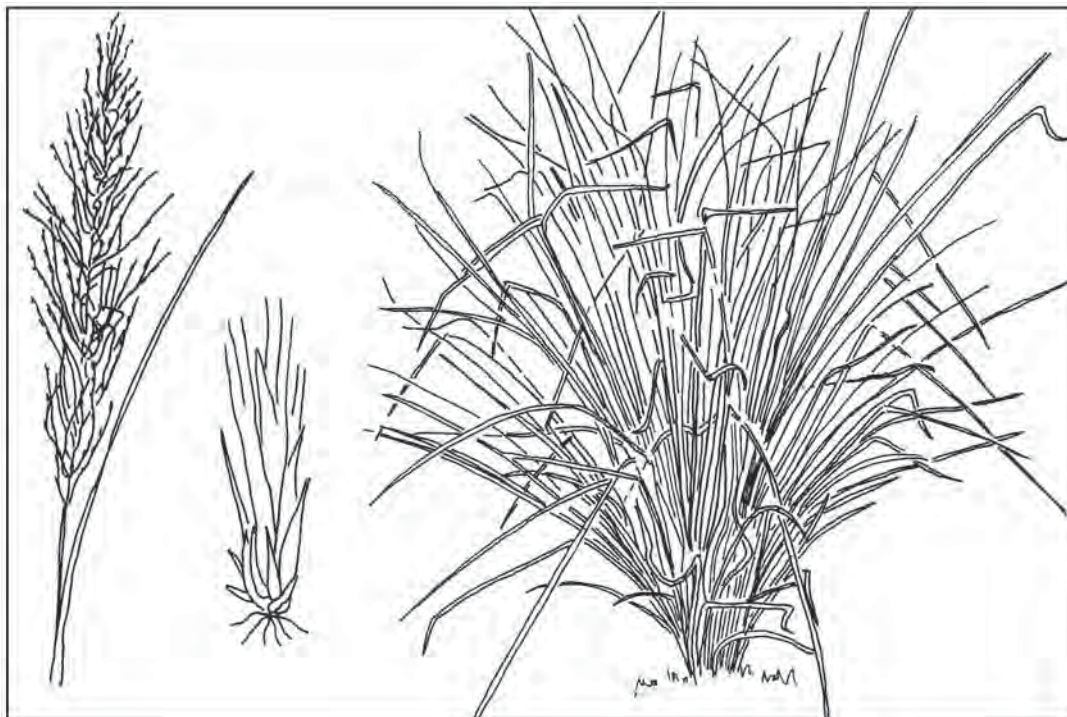
- On the contour within fields with moderate slopes
 - In rows across a drainage way
-

Plan your vegetative barriers

Plant Selection

Pacific Island farmers often grow vetivergrass (*Vetiveria zizanioides* syn. *Chrysopogon zizanioides*) for vegetative barriers because it is stiff and dense, making it a good filter. It is a sterile grass that won't spread. It has few pests and tolerates fire. Vetivergrass is deeply rooted and doesn't interfere with the growth of most crops. This grass is inexpensive, easy to grow, and needs little care.

Other plants may also be used. For current planting suggestions for vegetative barriers, contact the local USDA NRCS field office.



Vetivergrass (*Vetiveria zizanioides* syn. *Chrysopogon zizanioides*)

For in-field vegetative barriers

- Plant level and across the slope, without any low spots where water can channel and break through. Barriers should be as close to the contour as possible with no more than a 1-2% grade.

Spacing for In-field Vegetative Barriers	
% Slope of Field	Spacing
10%	60 feet (18.3 meters)
20%	30 feet (9.1 meters)
30%	20 feet (6.1 meters)
40%	15 feet (4.6 meters)
50%	12 feet (3.7 meters)



For vegetative barriers across channels, plant at least 2 rows of closely spaced plants about 1½ ft (46 cm) apart.

- Plant 1 or 2 rows of plants closely together (no more than 6 inches apart) so that the plants can quickly grow together to form a barrier with no gaps.
- Protect the barrier from damage by preventing animals and machinery from crossing through it.
- If you are using herbicides, be careful not to damage the barriers by spraying too close to them.
- On steep slopes (25% and greater), use **hillside ditches** (423) and vegetative barriers together.

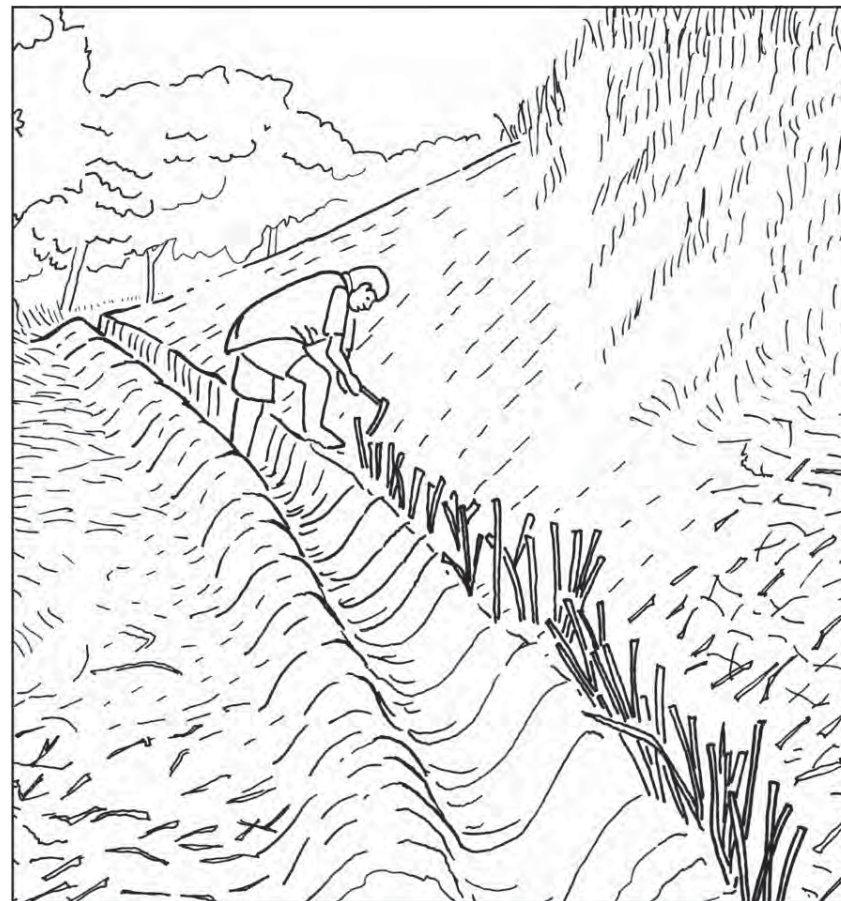
For vegetative barriers across channels

- Plant at least 2 rows of closely spaced plants about 1½ ft (46 cm) apart.
- Plant the barriers across the base of the gully and up the sides, about 1½ ft (50 cm) above the bottom of the channel. This is to stop water from flowing around the ends of the barrier during heavy rains.

For the best results, combine **vegetative barriers** with other conservation practices:

- On steep slopes (25% and greater) combine vegetative barriers with a **Hillside Ditch** (423): digging a small ditch across the slope to divert rainwater
- **Residue Management** (329): leaving slash in the field for soil protection
- **Contour Farming** (330): carrying out farm operations across the slope
- **Contour Farming for Orchards** (331): carrying out farm operations across the slope
- **Cover Crops** (340): growing crops to plow down and fertilize cash crops
- **Conservation Cover** (327): growing permanent plant cover to protect topsoil and smother weeds

Additional information is available from your local USDA Service Center or at www.pb.nrcs.usda.gov and www.hi.nrcs.usda.gov.



On steep slopes (25% and greater) combine vegetative barriers with hillside ditches.

